SEASONAL MOVEMENTS AND DISTRIBUTION OF SATELLITE-COLLARED CARIBOU COWS ON THE BOOTHIA AND SIMPSON PENINSULA AREAS, NORTHWEST TERRITORIES, 1991-93

Northwest Territories Resources, Wildlife & Economic Development

103-06764/

SEASONAL MOVEMENTS AND DISTRIBUTION OF SATELLITE-COLLARED CARIBOU COWS ON THE BOOTHIA AND SIMPSON PENINSULA AREAS, NORTHWEST TERRITORIES, 1991-93

A. GUNN,

B. FOURNIER

and

R. MORRISON

DEPARTMENT OF RESOURCES, WILDLIFE AND ECONOMIC DEVELOPMENT
GOVERNMENT OF THE NORTHWEST TERRITORIES
YELLOWKNIFE, NWT

2000

The research documented in this report was carried out prior to the creation of Nunavut. Final report preparation was funded by the Government of Nunavut.

Manuscript Report No.126

THE CONTENTS OF THIS REPORT ARE THE SOLE RESPONSIBILITY OF THE AUTHORS.

ABSTRACT

We fitted nine caribou (*Rangifer tarandus*) cows with satellite collars in the northeast Kitikmeot to describe seasonal movements and to determine from calving and rutting distribution the number of caribou herds wintering close to Taloyoak and Pelly Bay in 1991. We fitted six collars south of Taloyoak and three collars near Pelly Bay in March 1991. We had calving and rutting locations for seven cows in 1991 (two transmitters failed in 1991) as we received locations continuously for seven of the nine collared cows for 9 months from mid-April to December 1991. In 1992, we had calving and rutting locations for four cows and calving locations for the two additional cows located by radio-tracking as their satellite transmitters had failed in 1991. Three cows had died in 1992. Regular satellite reception ended during October – November 1992 but we delayed collar retrieval until June 1993 to acquire a third year of calving locations. Cows south of Taloyoak migrated north and arctic-island caribou calved on northwest Boothia Peninsula while barren-ground caribou calved on eastern Boothia. The caribou summered on the Peninsula and migrated south of Taloyoak for the rut. Discrimination of spatial separation of rutting distribution for the two types of caribou was incomplete. In contrast, the three caribou collared near Pelly Bay each had geographically separate calving locations and two cows had separate rutting areas (the third cow's transmitter failed). Our results suggest that caribou wintering near Pelly Bay in 1991 can be provisionally assigned to three herds and the caribou wintering near Taloyoak in 1991 can be provisionally assigned to two herds.

TABLE OF CONTENTS

ABSTRACT ii
LIST OF FIGURES iv
LIST OF TABLES vi
INTRODUCTION 1
METHODS 2
RESULTS 6
DISCUSSION 35
ACKNOWLEDGEMENTS 43
PERSONAL COMMUNICATION 44
REFERENCES 45

Appendix A. Description of cows fitted with satellite-collars, March 1991 48
Appendix B. Maps of individual movements for satellite-collared caribou on Boothia and Simpson peninsulas, 1991 and 1992. 50
Appendix C. Location data and distance traveled for satellite-collared caribou cows on Boothia Peninsula, 1991-93. 58

LIST OF FIGURES

Figure 1. The Boothia and Simpson peninsula study areas (1991-1993), NWT. 5

Figure 2. Capture sites of satellite-collared caribou cows on Boothia and Simpson peninsulas, NWT, 25-27 March1991. 7

Figure 3. Months and years for satellite transmissions from individual caribou, 1991- 92, on Boothia and Simpson peninsulas, NWT. 8

Figure 4. Flight lines on Boothia and Simpson peninsulas to verify calving, June 1991. 11

Figure 5. Probable calving locations of satellite-collared caribou cows on Boothia and Simpson peninsulas during June 1991, 1992 and 1993. 12

Figure 6. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for June 1991-93. 18

Figure 7. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for July 1991 and 1992. 19

Figure 8. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for August 1991 and 1992. 20

Figure 9. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for September 1991 and 1992. 21

Figure 10. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for October 1991 and 1992. 22

Figure 11. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for November 1991 and 1992. 23

Figure 12. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for December 1991. 24

Figure 13. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for January 1992. 25

Figure 14. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for February 1992. 26

Figure 15. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for March 1991 and 1992. 27

Figure 16. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for April 1991 and 1992. 28

Figure 17. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for May 1991 and 1992..... 29

Figure 18. Cluster analysis of satellite-collared caribou cow annual movements on Boothia and Simpson peninsulas relative to a fixed, random point outside the study area. 34

LIST OF TABLES

Table 1. Calving status of collared cows on Boothia and Simpson peninsulas, NWT, June 1991, 1992 and 1993. 10

Table 2. The minimum distance calculated between mid-June locations for satellite-collared cows in 1991 and 1992. 13

Table 3. Distance (km) measured between satellite locations during the rut for cows using Boothia Peninsula, October 1991. 15

Table 4. Distance measured between barren-ground and arctic island satellite-collared caribou during the rut in October 1991 on Boothia Peninsula. 15

Table 5. Total monthly straight-line distance traveled (km) by collared cows on Boothia Peninsula in 1991 and 1992. 31

Table 6. Between-year comparison of daily distance traveled, May - September, between 1991 and 1992. 32

Table 7. Relative distances in km between satellite-collared cows calculated from distances between cows at calving and rut. 34

INTRODUCTION

The increase in caribou (*Rangifer tarandus*) numbers wintering each year near Taloyoak and Pelly Bay between the mid-1970s and mid-1980s (Gunn and Ashevak 1990) raised questions about which herds were using the area. During their 1985 aerial survey, Gunn and Ashevak (1990) noted calving north and south of Taloyoak and discussions with hunters at Pelly Bay identified other calving areas (summarised in Gunn and Fournier 2000a). Although Gunn and Ashevak (1990) recommended aerial surveys and genetic studies to identify herds and seasonal distributions, satellite telemetry is more cost-effective than aerial surveys to determine seasonal movements. This is especially true for calving and rutting distribution, which in turn can be used to define herds. The accurate and frequent location transmissions facilitate seasonal movement studies during dark arctic months and unfavorable weather conditions especially in remote areas (Fancy *et al.* 1989).

Our objectives for using satellite telemetry in the northeast Kitikmeot were to describe seasonal movements and to determine from calving and rutting distribution the number of caribou herds wintering close to Taloyoak and Pelly Bay in the early 1990s. Our approach included aerial surveys during calving to verify if the collared cows had calved and to describe if other cows were calving in their vicinity. Those surveys are reported in a compendium on calving distribution (Gunn and Fournier 2000a) and this report describes the telemetry results.

METHODS

The collars (ST6, Telonics Inc. Arizona, U.S.A.) were refurbished collars from a previous study and were programmed with a 6 hours on and 114 hours off duty cycle, except during June when they transmitted 6 hours on and 18 hours off. This normally resulted in receiving location data every 5 days, except in June when data was received daily.

To fit the collars, we searched for caribou in areas identified by hunters and attempted to spread the collars in as many areas as practical. We used a Bell 206b Jet Ranger helicopter flown at an altitude of 75 to 150 m above ground level and at cruising speed (140 km/h). From the air, we scrutinized caribou groups for animals with hard antlers and short yearlings to identify cow groups. Those groups were checked more closely to ascertain that adult cows were present (presence of a vulval patch). We used a hand-held net-gun to catch a cow. We restricted pursuits to <60 sec when ambient air temperatures were > -35°c. No animal was pursued for >120 sec when ambient air temperatures were < -35°c. The short chases were to minimize respiratory distress from the cold air and conversely to reduce the possibility of overheating. We aborted chases if the pursued caribou headed to wind-blown bare ground or rocky areas in order to reduce the likelihood of injuries.

We blindfolded and manually restrained the cows, checked that the cow had fully erupted dentition and fitted the collar. The satellite collar was fitted to allow three fingers to slip between the collar and the neck. We released the cow as soon as the collar was fitted and the restraining nuts tightened. To reduce the handling time, we took no measurements or samples.

Calving Distribution

We located cows to confirm calving in June 1991, 1992 and 1993 using the satellite location and VHF radio-tracking from a fixed-wing Helio-Courier aircraft

on wheel skis. We visually determined if the instrumented cow had a calf and hard antlers and if we saw other calving cows in her vicinity. In 1991, we surveyed in the vicinity of the collared cow but in the subsequent 2 years, fewer aircraft hours were available. The maps of the flightlines were lost for the 1992 and 1993 surveys; we used observations recorded in field notes. Aircraft altitude was 120 - 130 m above ground level and airspeed was 160 km/h.

Data Analysis

We plotted location data using Quikmap and Freelance software. We calculated the daily distance moved, and total monthly and annual distances moved for each cow using Dbase5. Because the data was inconsistent (ie. not received every day), we could not compare daily locations in June. To estimate the timing of calving, we examined the daily distance moved (calculated from 5 day satellite locations) in June to determine the period of least activity and distance moved. We tested fidelity to calving area by measuring the distance between annual calving locations using survey location data for confirmed calving and satellite location data for cows not seen or that had not yet calved. The distance between arctic-island and barren-ground collared cows using Boothia Peninsula was measured during the rut (October) using Spans Mapping (7.1) to determine if the cows were in close proximity at this time. Because the test for normality failed, the Mann-Whitney Rank Sum test was run (SigmaStat) to determine if there were significant differences between individuals and between years of monthly distances travelled.

We applied a cluster analysis on individual measured distances from a fixed random point outside of the study area during calving and rut (2 June – 15 July, 8 - 28 October). Then we used a Pearson Product Moment test to compare these distances and identify which cows had similar movements and therefore clustered together.

Distances were calculated in km between cows using 3 locations during calving (2 June – 15 July, 1991) and 3 locations during the rut (8 – 28 Oct, 1991). The mean distance between cows for each period was calculated and these two figures were used to calculate a simple arithmetic mean to show the relative distance between cows to represent association.

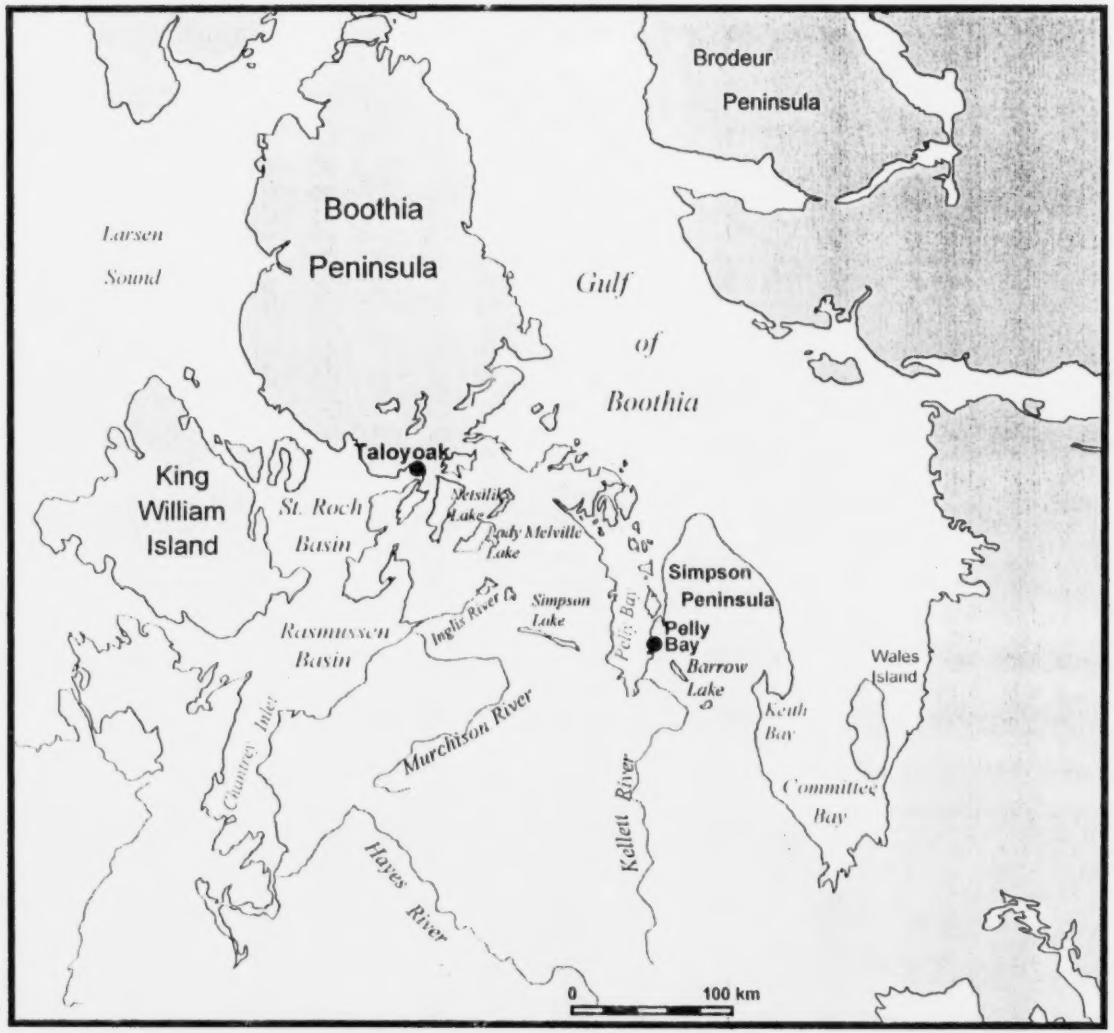


Figure 1. The Boothia and Simpson peninsula study areas (1991-1993), NWT.

RESULTS

We fitted satellite collars on nine caribou cows at four locations (Figure 2). Four caribou were collared on 25 March, three on 26 March, and the last two on 27 March 1991. Three of the nine cows were arctic-island (7762, 7769 and 7771), and six were barren-ground based on their appearance (Appendix A).

We had calving and rutting locations for seven cows in 1991 as we received locations continuously for seven of the nine collared cows for 9 months from mid-April to December 1991 (Figure 3). Satellite reception failed initially for cows 7764 and 7766 in June and May 1991, respectively. Reception resumed but failed again 1 month later for 7764 and in mid-October 1991 for 7766.

In 1992, we had calving and rutting locations for only four cows from satellite data, but calving locations were also obtained for cows 7764 and 7766 as both cows were located by VHF during June 1992 (even though their satellite transmitters had failed in 1991). Two cows (7765 and 7771) had died during January 1992 and cow 7769 died in March 1992, based on the satellite locations not changing and zero long-term activity counts.

Regular satellite reception ended during October – November 1992 but we delayed collar retrieval until June 1993 to acquire a third year of calving locations. During the fixed-wing survey in June 1993, cows 7764, 7767 and 7768 were located and shot and their collars retrieved. Cow 7766 was found dead in June 1993. Cows 7760 and 7762 were not located. Possibly, they were out of the VHF range and the collars were not retrieved. Only one of the three collars of cows that died in 1992 was recovered in June 1992 and other two collars were not found possibly because they were buried under the snow or in a fox den.

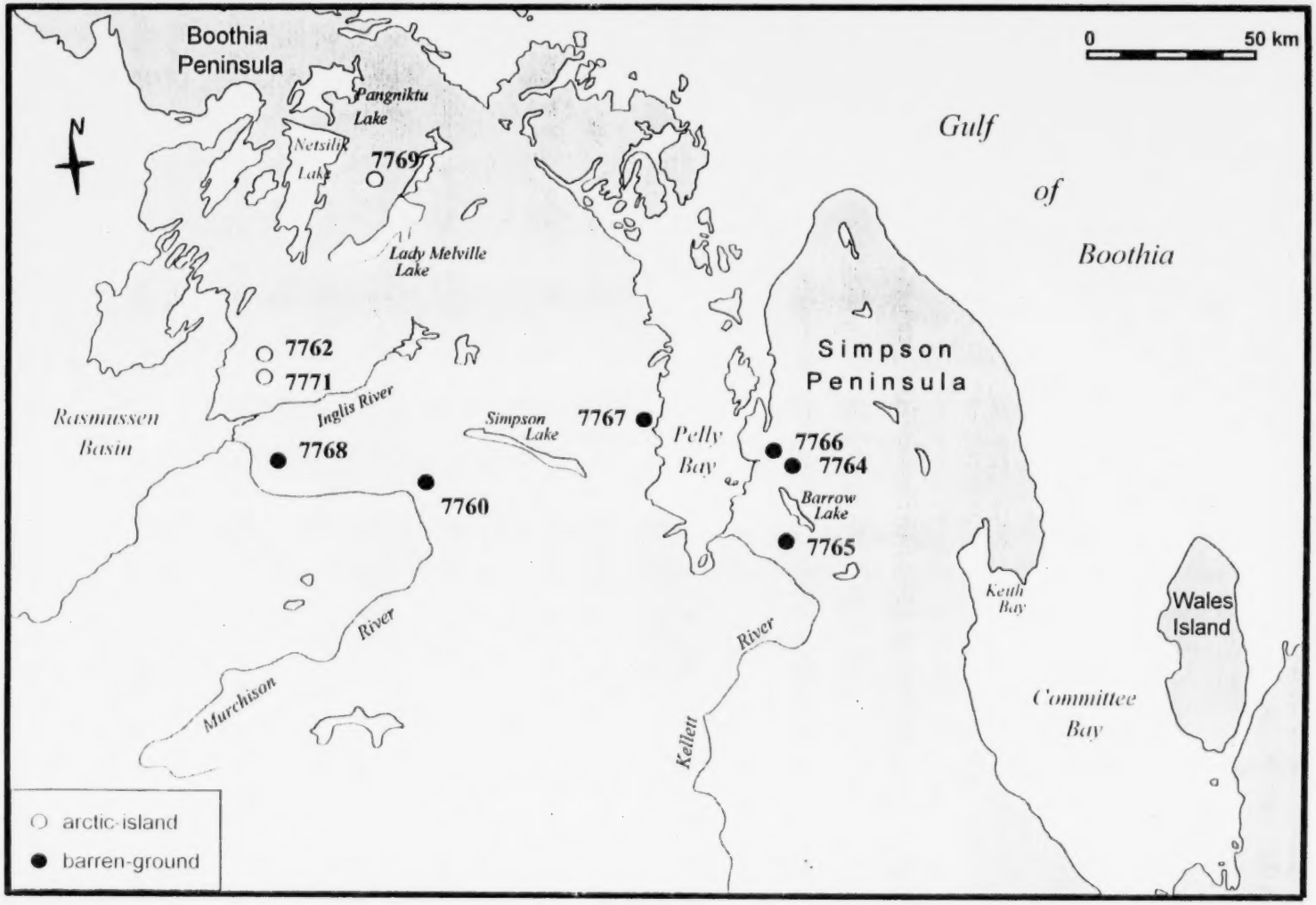


Figure 2. Capture sites of satellite-collared cows on Boothia and Simpson peninsulas, NWT, 25-27 March 1991.

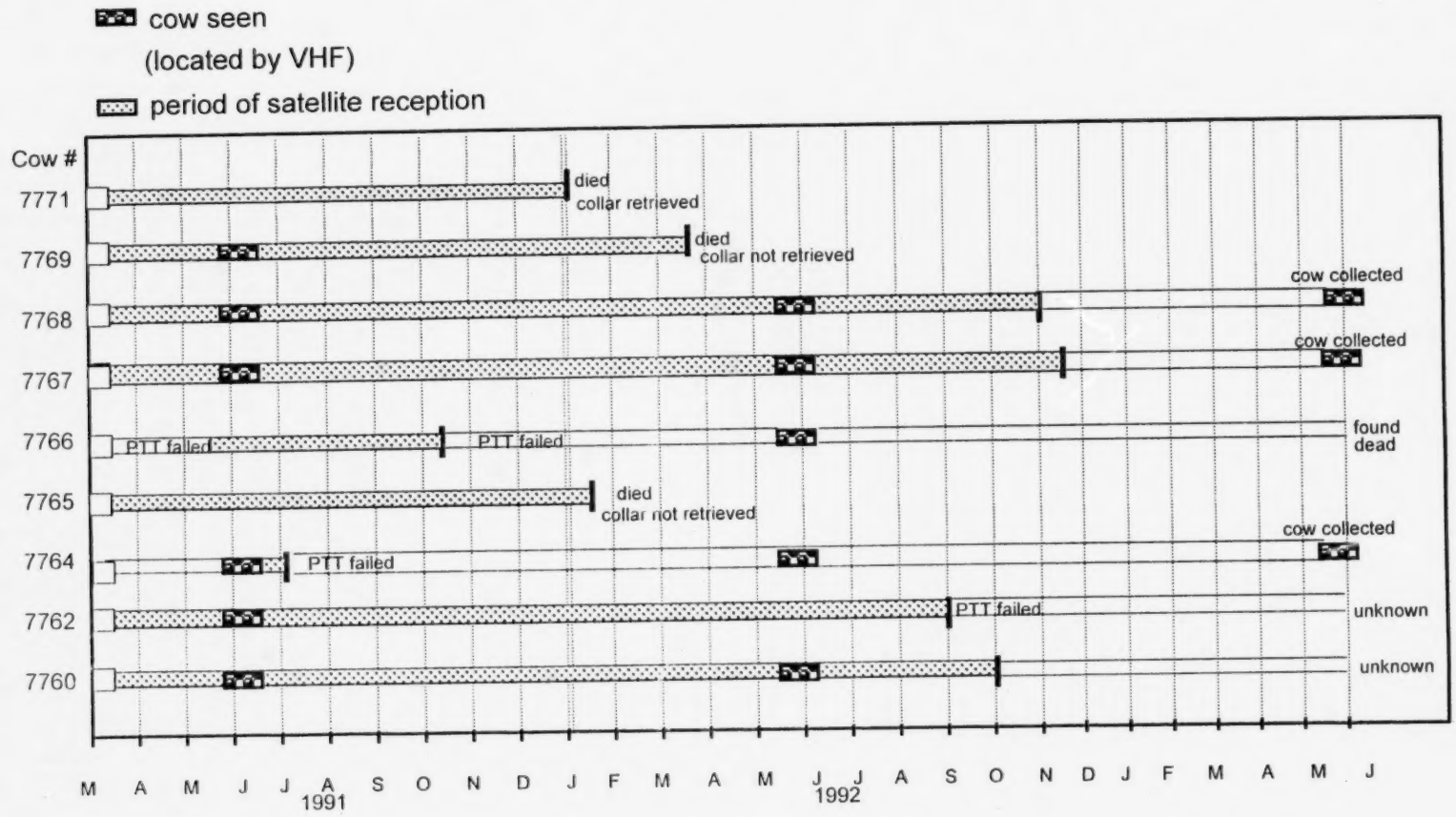


Figure 3. Months and years for satellite transmissions from individual caribou, 1991-92, on Boothia and Simpson peninsulas, NWT.

Calving Locations

During the first calving season survey, 12-14 June 1991, we located six of the nine collared cows to verify calving status (Figure 4 and Table 1). Three cows had calves and still hard antlers; two had hard antlers and one cow had no antlers. We could not determine whether the unantlered cow had calved, lost her calf and shed her antlers or whether she was barren but had no new antlers growth. We had satellite location data for the three cows (7765, 7766 and 7771) that could not be located by VHF (Figure 5). We determined possible calving locations for these three cows by examining satellite activity data and daily movements during June. We chose calving dates where movement and activity were minimal.

Between 15 and 19 June 1992, we found four of the six cows seen in June 1991 (Table 1) and one cow not seen in 1991. No cows had calved but the four cows had hard antlers suggesting that they were pregnant and the one unantlered cow was followed by a yearling. On 9 and 10 June 1993, one of the three cows seen had calved, one was pregnant and one was unantlered. For those three cows, it was the 3rd consecutive year that we had determined calving status.

The three arctic-island cows (7762, 7769 and 7771) were on northwestern Boothia Peninsula in June 1991 along with three barren-ground cows (7760, 7767 and 7768) (Figures 5 and 6). Cow 7764 was on the northern part of the Simpson Peninsula and cow 7766 was on the west side of Pelly Bay during June 1991. Cow 7765 was not seen during the 1991 aerial survey but her satellite position was north of Repulse Bay during June 1991 (Figure 5).

We had a 2nd year of calving locations for four cows (7760, 7762, 7767 and 7768) based on satellite locations and for two additional cows with non-functioning satellite transmitters (7764 and 7766) using VHF tracking during the calving survey, 15-21 June 1992 (Table 1). We documented a third June

location for cows 7764, 7768 and 7767 during the final location survey, 8-10 June 1993 (Table 1 and Figure 5).

Table 1. Calving status of collared cows on Boothia and Simpson peninsulas, NWT, June 1991, 1992 and 1993.

Date	Cow								
	7762	7769	7771	7764	7765	7766	7760	7767	7768
1991									
June 12	hard antlers, calf	hard antlers, calf	unseen		unseen				hard antlers, calf
13							hard antlers	no antlers	
14				hard antlers		unseen			
1992									
June 15	unseen	dead	dead		dead				hard antlers
16							hard antlers	hard antlers	
18				no antlers yearling		hard antlers			
19									
1993									
June 9	un-known	--	--		--	dead	un-known	no antlers	
10				hard antlers yearling					hard antlers, calf

Collared cows returned to the same general location to calve from 1991 to 1993 (Figure 5 and 6). Cows 7760, 7762 and 7768 returned to northern Boothia Peninsula and individual mid-June locations in 1991 were 75 – 99 km from 1992 locations (Table 2). The dates used to calculate the distance between a calving

location for cows 7764, 7768 and 7767 during the final location survey, 8-10 June 1993 (Table 1 and Figure 5).

Table 1. Calving status of collared cows on Boothia and Simpson peninsulas, NWT, June 1991, 1992 and 1993.

Date	Cow								
	7762	7769	7771	7764	7765	7766	7760	7767	7768
1991									
June 12	hard antlers, calf	hard antlers, calf	unseen		unseen				hard antlers, calf
13							hard antlers	no antlers	
14				hard antlers		unseen			
1992									
June 15	unseen	dead	dead		dead				hard antlers
16							hard antlers	hard antlers	
18				no antlers yearling		hard antlers			
19									
1993									
June 9	un-known	--	--		--	dead	un-known	no antlers	
10				hard antlers yearling					hard antlers, calf

Collared cows returned to the same general location to calve from 1991 to 1993 (Figure 5 and 6). Cows 7760, 7762 and 7768 returned to northern Boothia Peninsula and individual mid-June locations in 1991 were 75 – 99 km from 1992 locations (Table 2). The dates used to calculate the distance between a calving

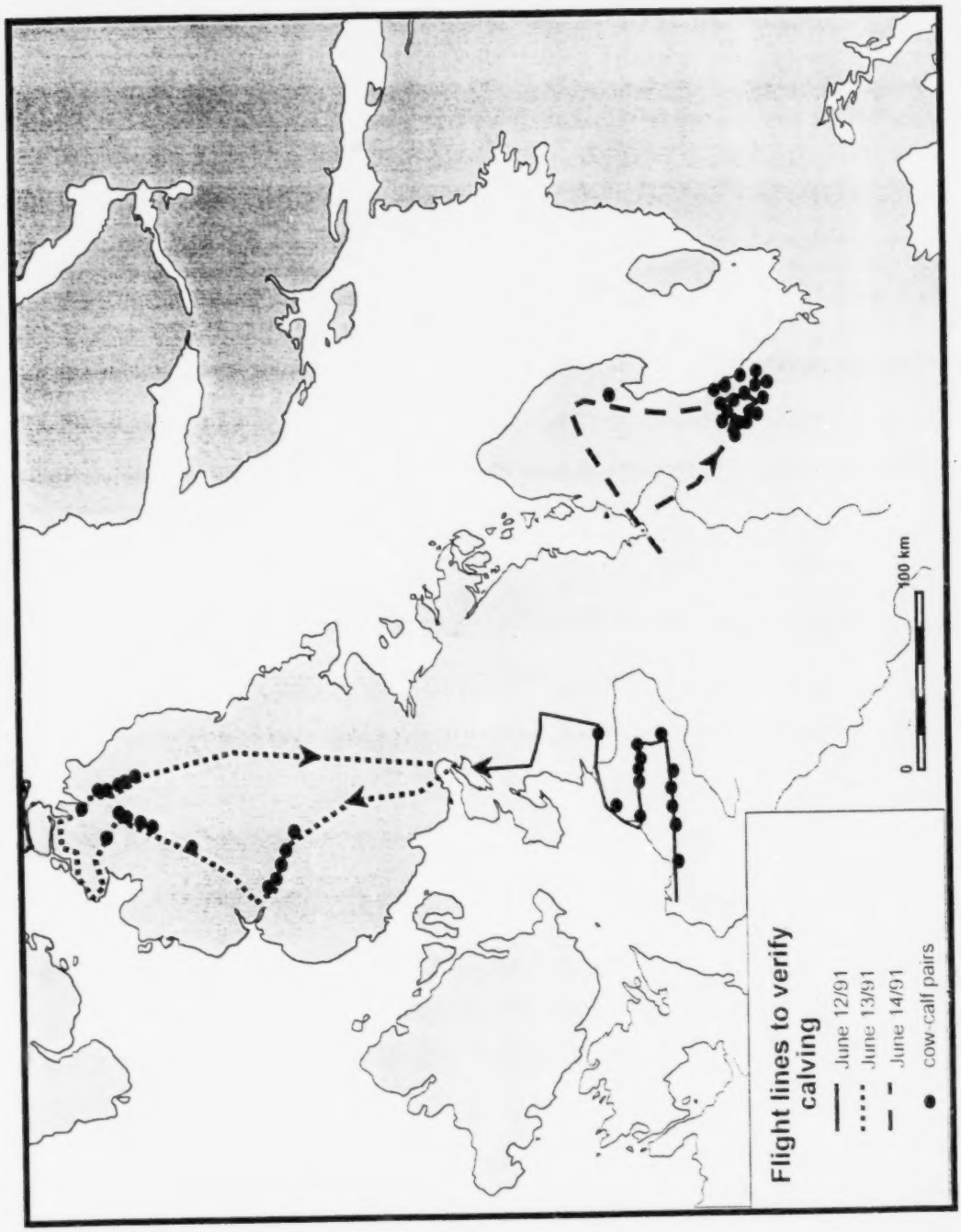


Figure 4. Flight lines on Boothia and Simpson peninsulas to verify calving, June 1991.

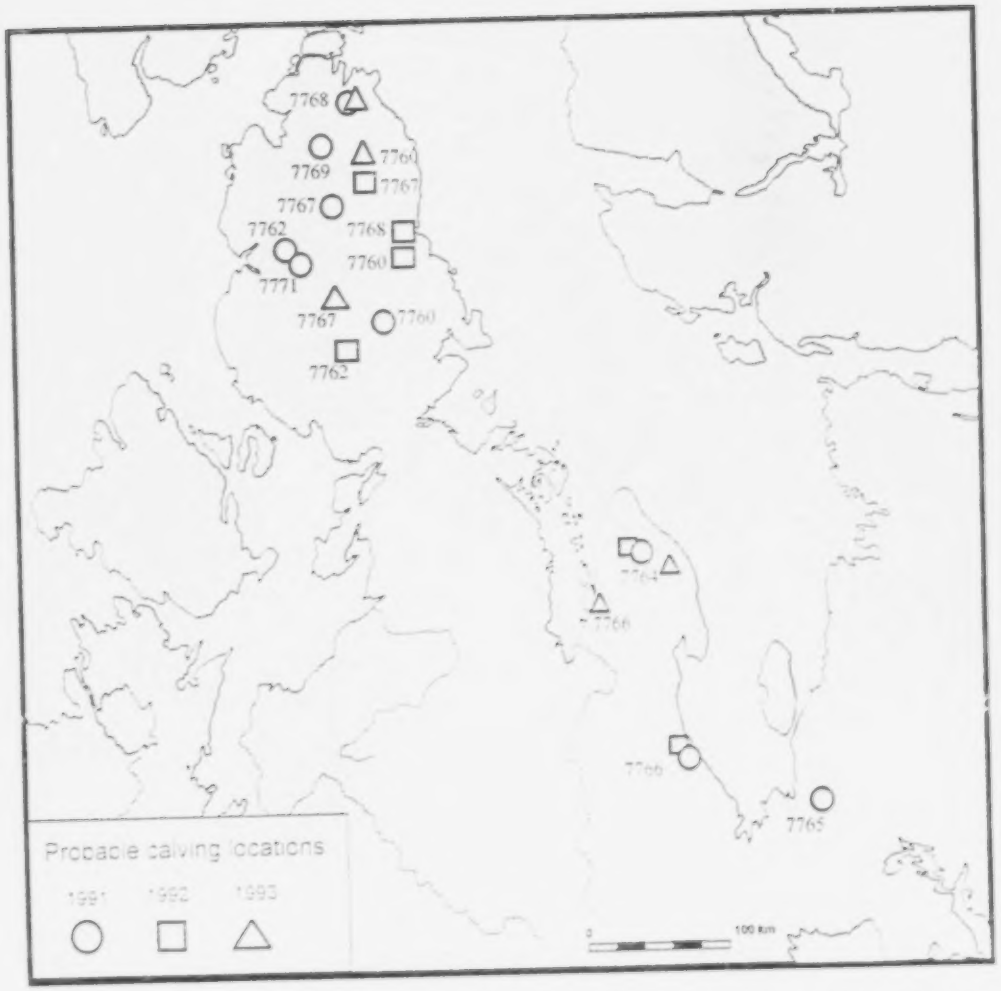


Figure 5. Probable calving locations of satellite-collared caribou cows on Boothia and Simpson peninsulas during June 1991, 1992, and 1993

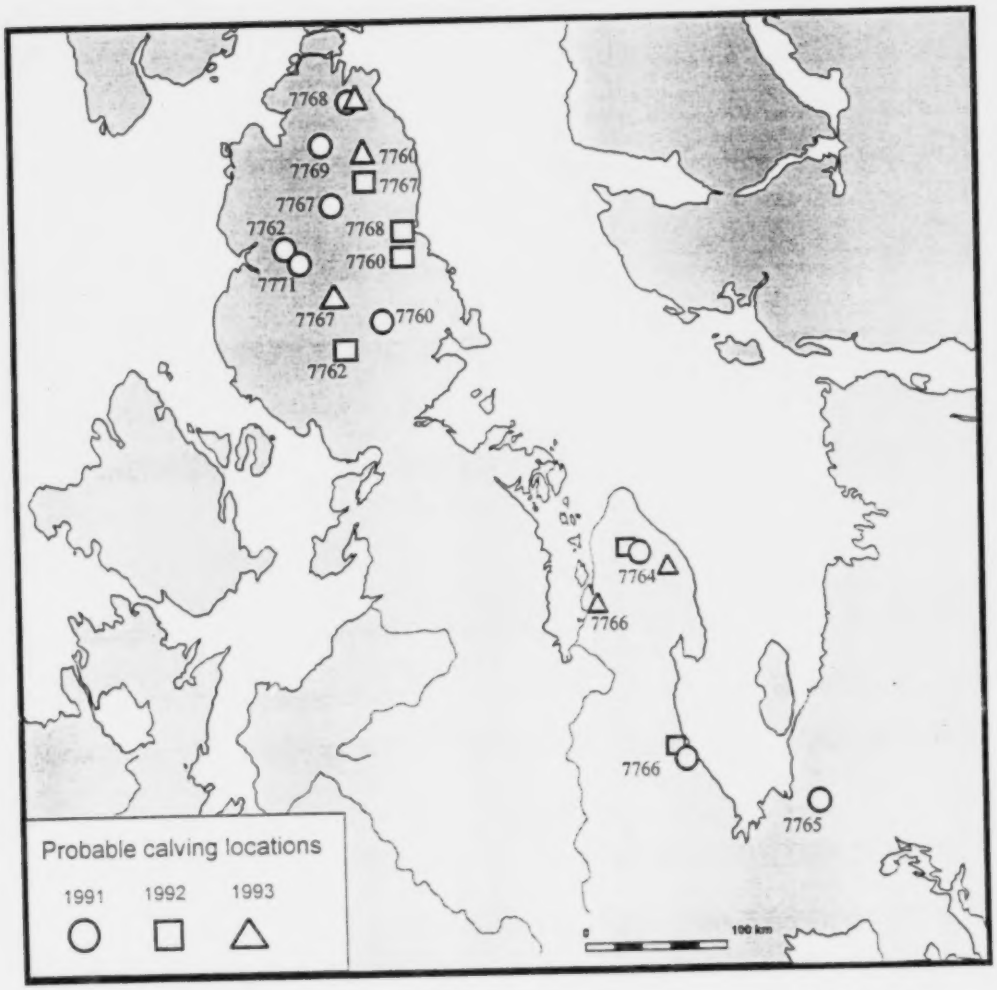


Figure 5. Probable calving locations of satellite-collared caribou cows on Boothia and Simpson peninsulas during June 1991, 1992, and 1993.

location in 1991 and calving location in 1992 were chosen from survey data or from satellite location data if the cow was not located during a survey. Although her collar failed in June 1992, cow 7766 was located along the west coast of Pelly Bay by VHF during the calving survey and this location was about 8 km from its 1991 satellite location in mid-June.

Table 2. The minimum distance calculated between mid-June locations for satellite-collared cows in 1991 and 1992.

Cow #	1991 date	1992 date	DISTANCE (km)
7760	June 19*	June 19*	89.5
7762	June 12	June 16*	75.1
7766	June 13*	June 18	7.5
7768	June 12	June 15	99.6

*approximate date of minimal movement from satellite location data

Seasonal Distribution

After calving in July 1991 and 1992, the caribou on Boothia Peninsula and Simpson Peninsula did not have extensive postcalving movements but remained in the vicinity of the calving areas (Figure 7). In August 1991 and 1992, the caribou on Boothia Peninsula were starting to move south (Figure 8) and this southern movement continued in September (Figure 8).

We use the October locations (Figure 10) to indicate rutting distribution for 1991 and 1992 as we do not have visual observations to determine the peak of rutting. The seasonal distribution for the three barren-ground cows (7760, 7767 and 7768) that calved and summered on Boothia Peninsula was similar to the three arctic-island caribou (7762, 7769, and 7771). Both groups rutted in the same area (Figure 10) and distances compared between them were similar (Tables 3 and 4). The mean distance between the three arctic-island cows (7762, 7769 and 7771) in mid-October was 69±14.8 (SE) km, compared to a mean of 43±6.2 (SE) km between the barren-ground cows that had been on the northeast Boothia Peninsula in June (Table 3). We paired a barren-ground cow with the nearest arctic-island cow and the mean distance between those pairs at mid-October was 32±3.6 (SE) km (Table 4).

Table 3. Distance (km) measured between satellite locations during the rut for cows using Boothia Peninsula, October 1991.

cow #	date	distance (km) between October locations	
barren-ground		7767	7768
7760	Oct 03	43	37
	Oct 08	79	68
	Oct 13	55	40
7768	Oct 03	37	
	Oct 08	26	
	Oct 13	34	
arctic-island		7769	7771
7762	Oct 03	66	62
	Oct 08	44	91
	Oct 13	54	99
7771	Oct 03	5	
	Oct 08	48	
	Oct 13	55	

Table 4. Distance measured between barren-ground and arctic island satellite-collared caribou during the rut in October 1991 on Boothia Peninsula.

arctic island cow	barren-ground cow	date	distance (km) between cows
7769	7768	Oct 3	6 km
7769	7768	Oct 8	25 km
7769	7768	Oct 13	48 km
7769	7768	Oct 18	27 km
7769	7768	Oct 23	16 km
7769	7768	Oct 28	26 km
7771	7767	Oct 3	38 km
7771	7767	Oct 8	26 km
7771	7767	Oct 13	5 km
7771	7767	Oct 18	28 km
7771	7767	Oct 23	12 km
7771	7767	Oct 28	14 km

arctic island cow	barren-ground cow	date	distance (km) between cows
7762	7760	Oct 3	31 km
7762	7760	Oct 8	13 km
7762	7760	Oct 13	43 km
7762	7760	Oct 18	80 km
7762	7760	Oct 23	26 km
7762	7760	Oct 28	24 km

The three arctic-island caribou that had calved and summered on the northwest Boothia Peninsula near Wrottsley Inlet continued to migrate south after the rut during November 1991 (Figures 10 and 11). Two of the three cows continued to move south and by January 1992 were in the vicinity of the Hayes River and Chantry Inlet, where they both died by March 1992 (Figures 12 – 15). The third arctic–island caribou (7762) wintered about 75 km north of the other two collared arctic-island cows, and her March movements were northeast to the northwest coast of Pelly Bay before migrating back to the northwest Boothia Peninsula for calving and summer.

The barren-ground cows migrated south between August and November (Figures 8 – 12) and then returned to Boothia Peninsula in April and May (Figures 13 – 17). We had data for cow 7767 until 17 November 1992. In the 1991/92 winter she was in the similar area to the other cows in the uplands between the Hayes and Simpson rivers and north of the Murchison River. But in October 1992, cow 7767 travelled a 364 km straight-line distance south of her 1991/92 winter distribution almost to Baker Lake. Even though we do not have satellite data to describe her return migration, in June 1993 she was collected back on the northern Boothia Peninsula. She was unantlered, not pregnant and followed by a yearling and 2-year-old caribou.

Locations for cow 7766 covered less than 6 months, from June to mid-October 1991 and she remained on Simpson Peninsula (Appendix B). During this same time period, cow 7765 moved east from Simpson Peninsula to south-east of Committee Bay during calving. By September 1991, cow 7765 had returned to Simpson Peninsula, moved about 200 km west toward Chantry Inlet during October, wintered in the same area as the Boothia cows, and then died in January 1992 (Appendix B).

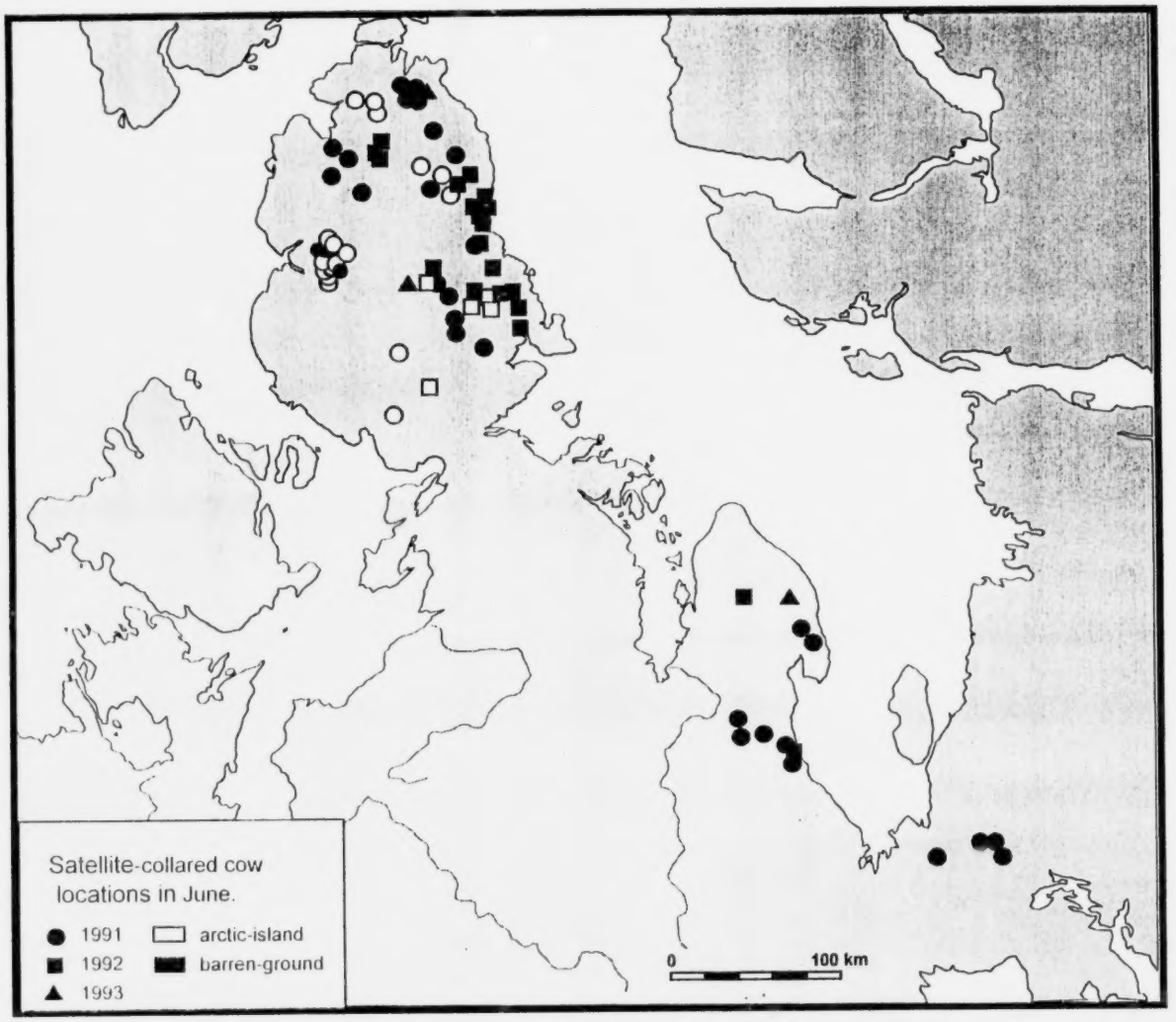


Figure 6. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for June 1991-93.

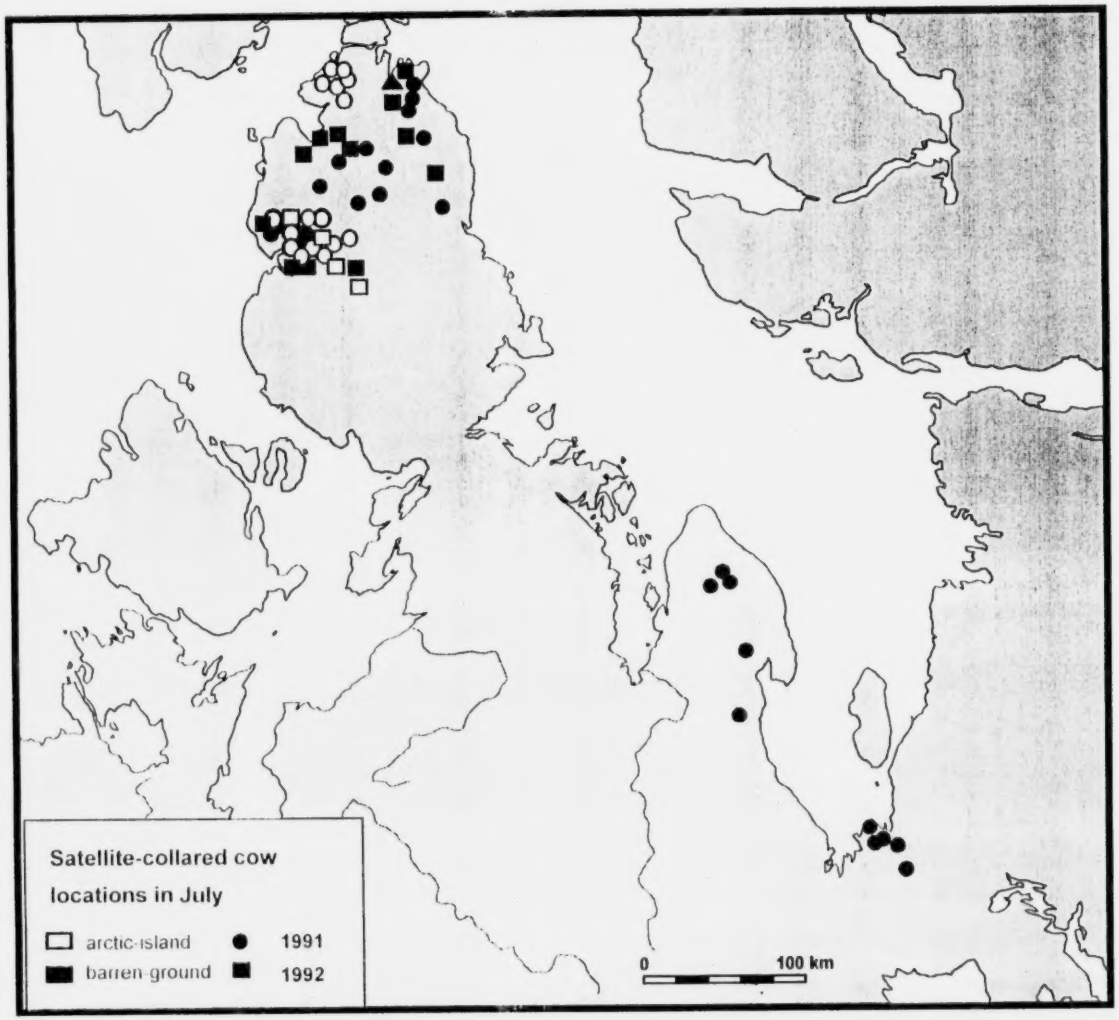


Figure 7. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for July 1991 and 1992.

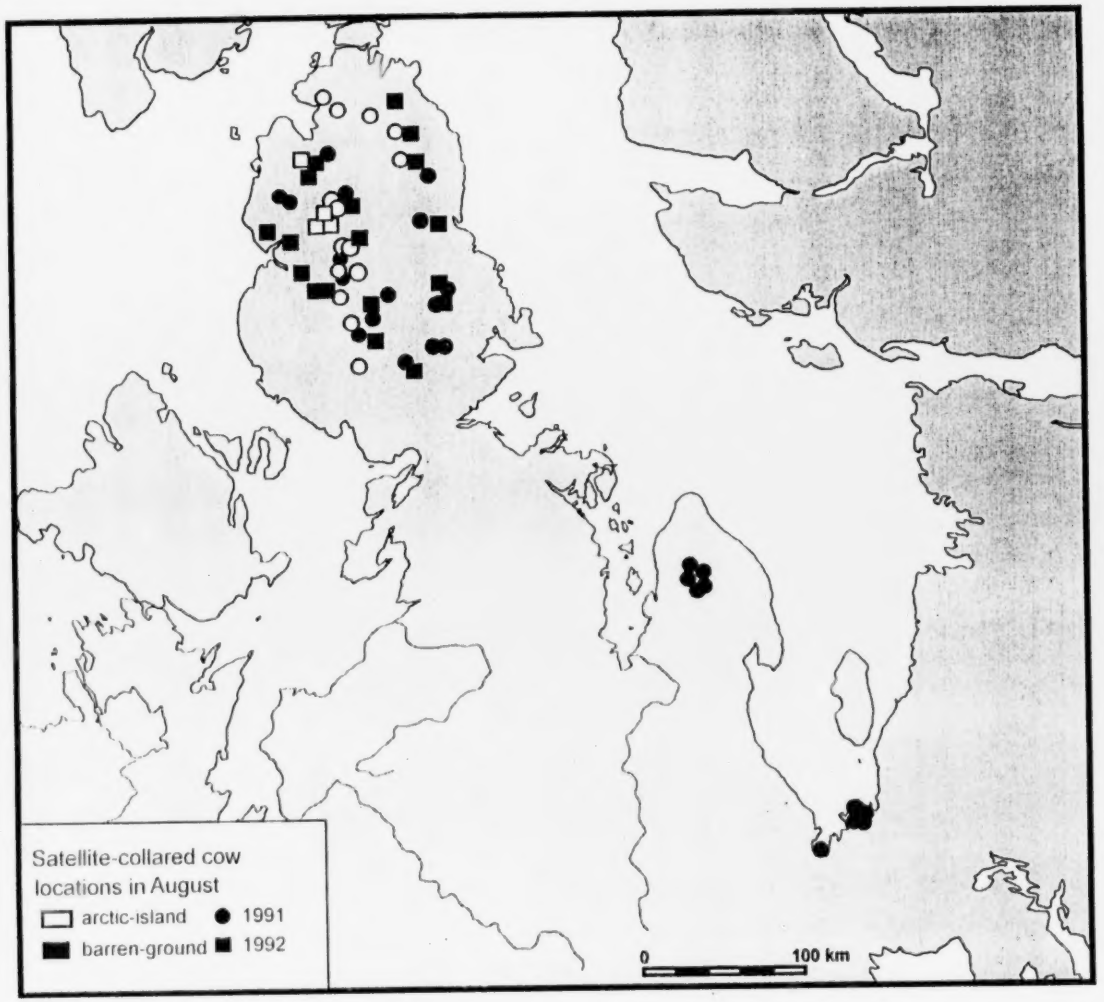


Figure 8. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for August 1991 and 1992.

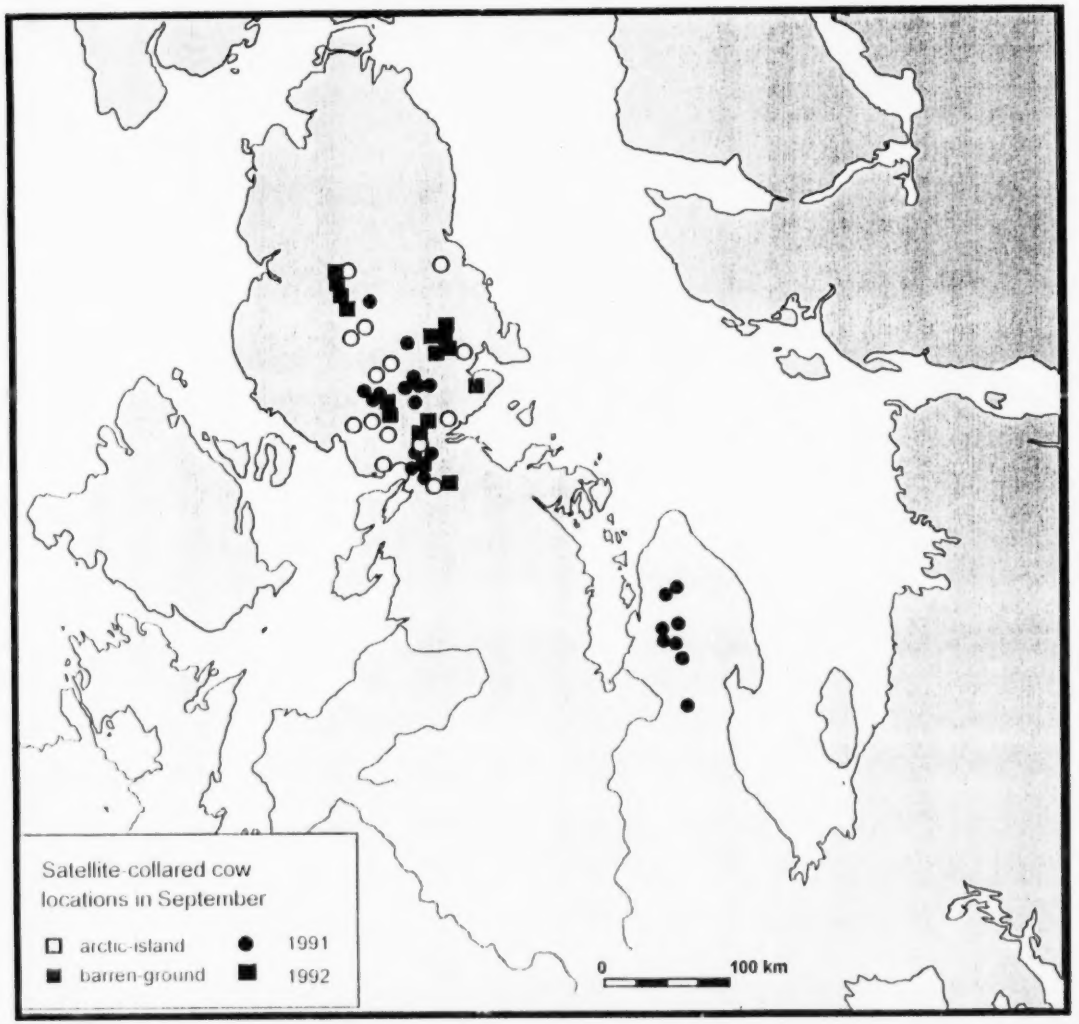


Figure 9. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for September 1991 and 1992.

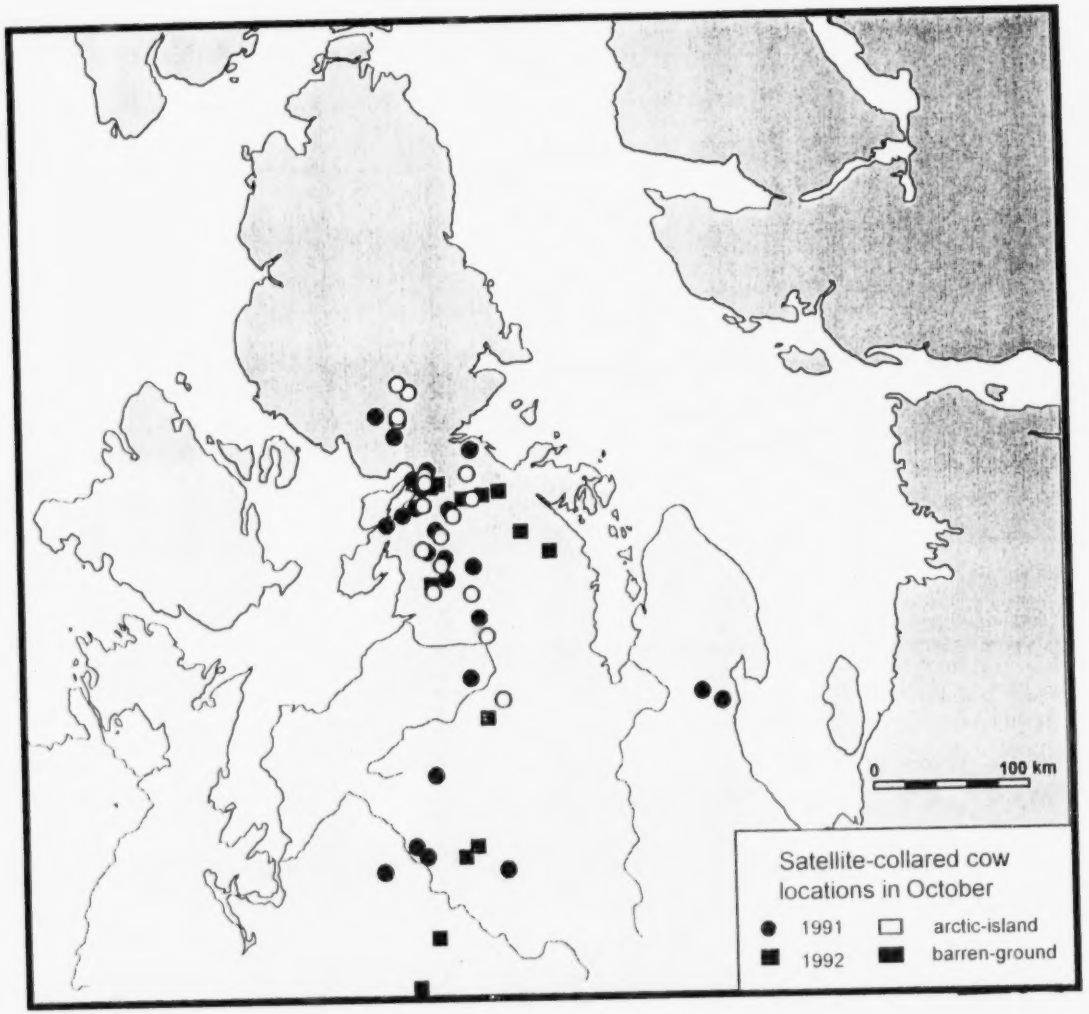


Figure 10. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for October 1991 and 1992.

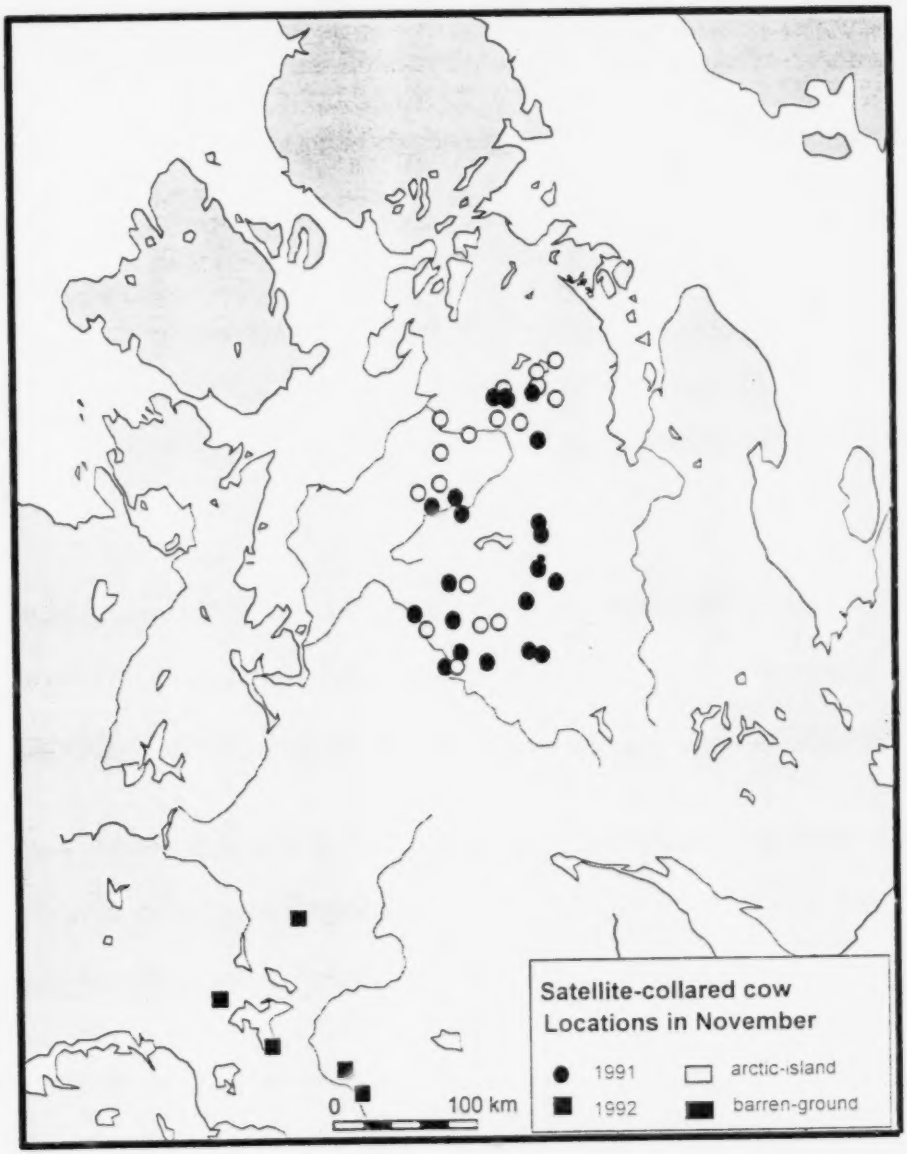


Figure 11. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for November 1991 and 1992.

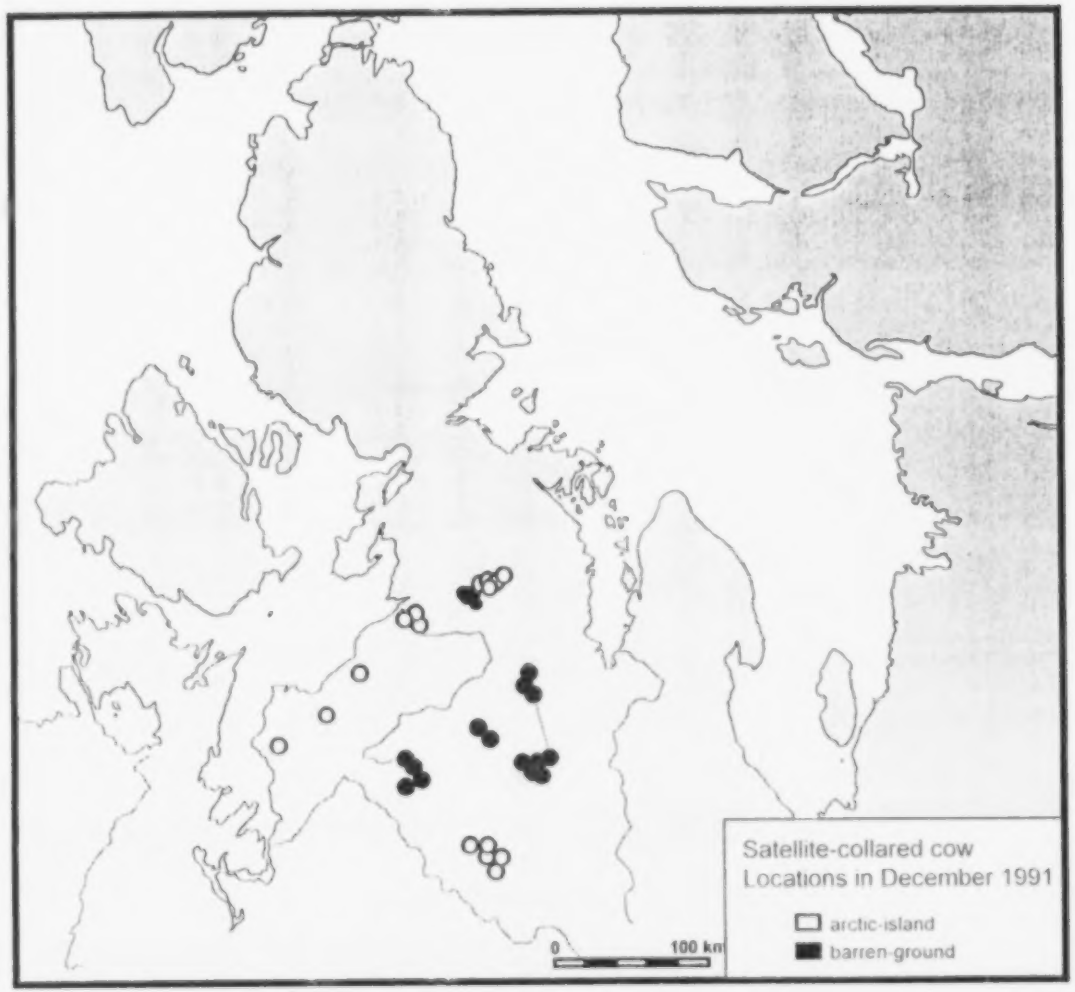


Figure 12. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for December 1991.

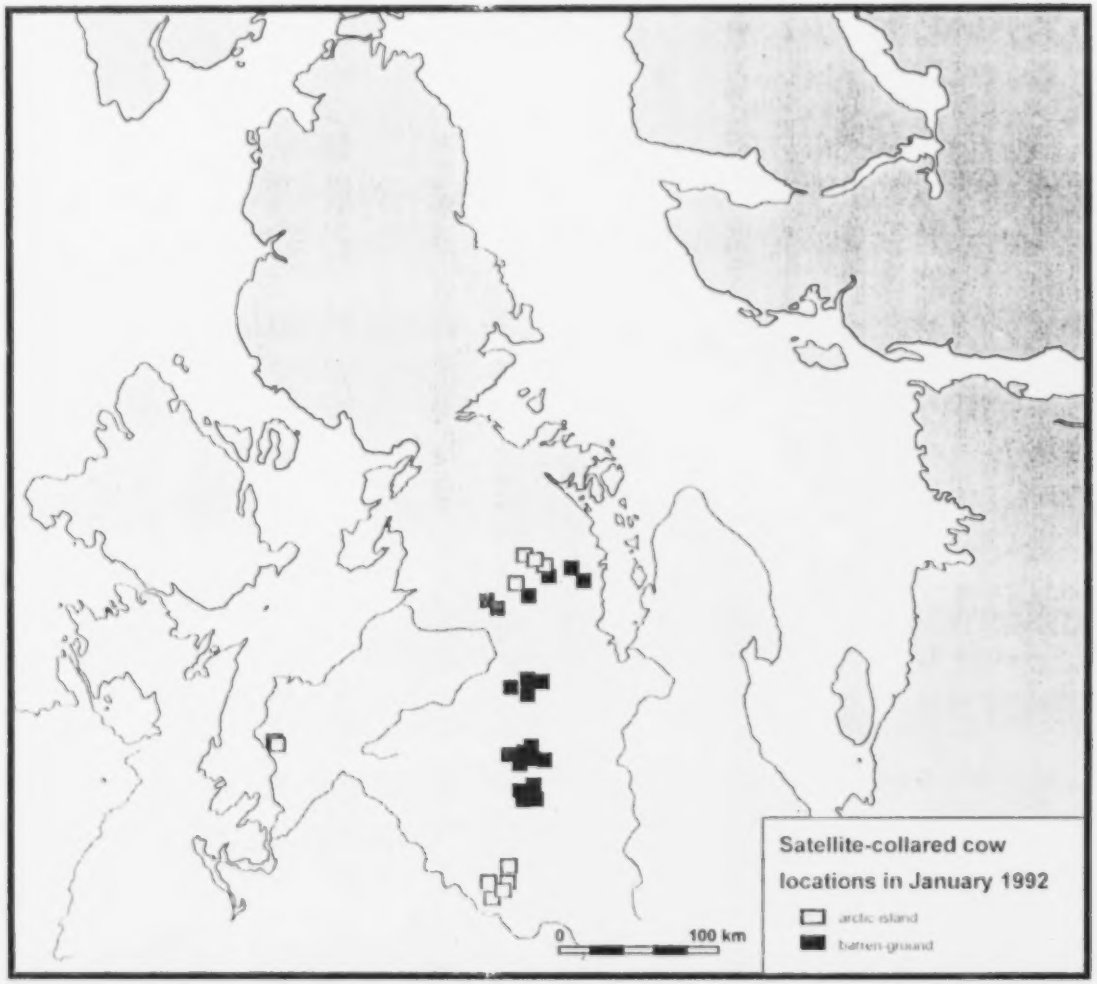


Figure 13. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for January 1992.

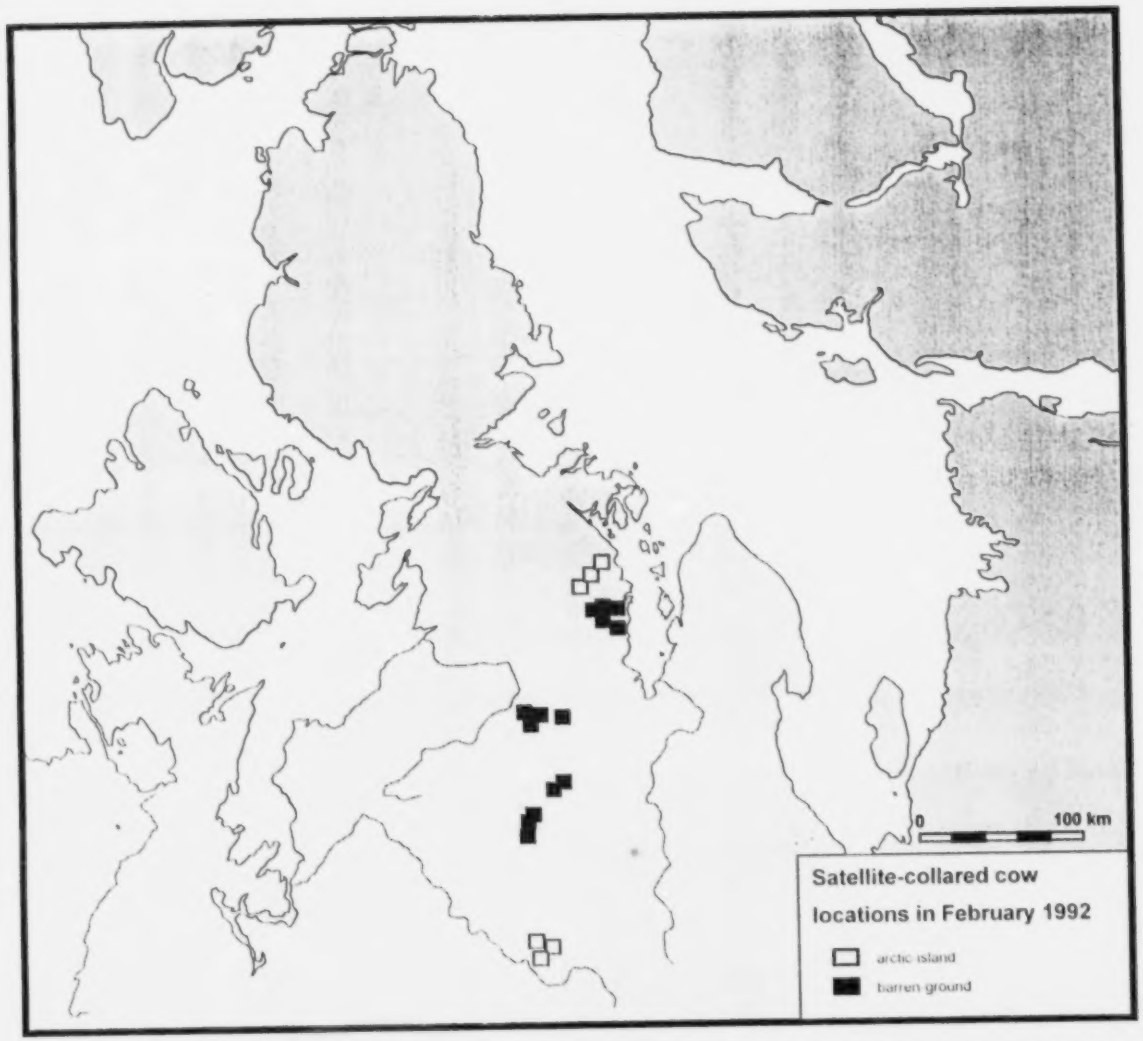


Figure 14. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for February 1992.

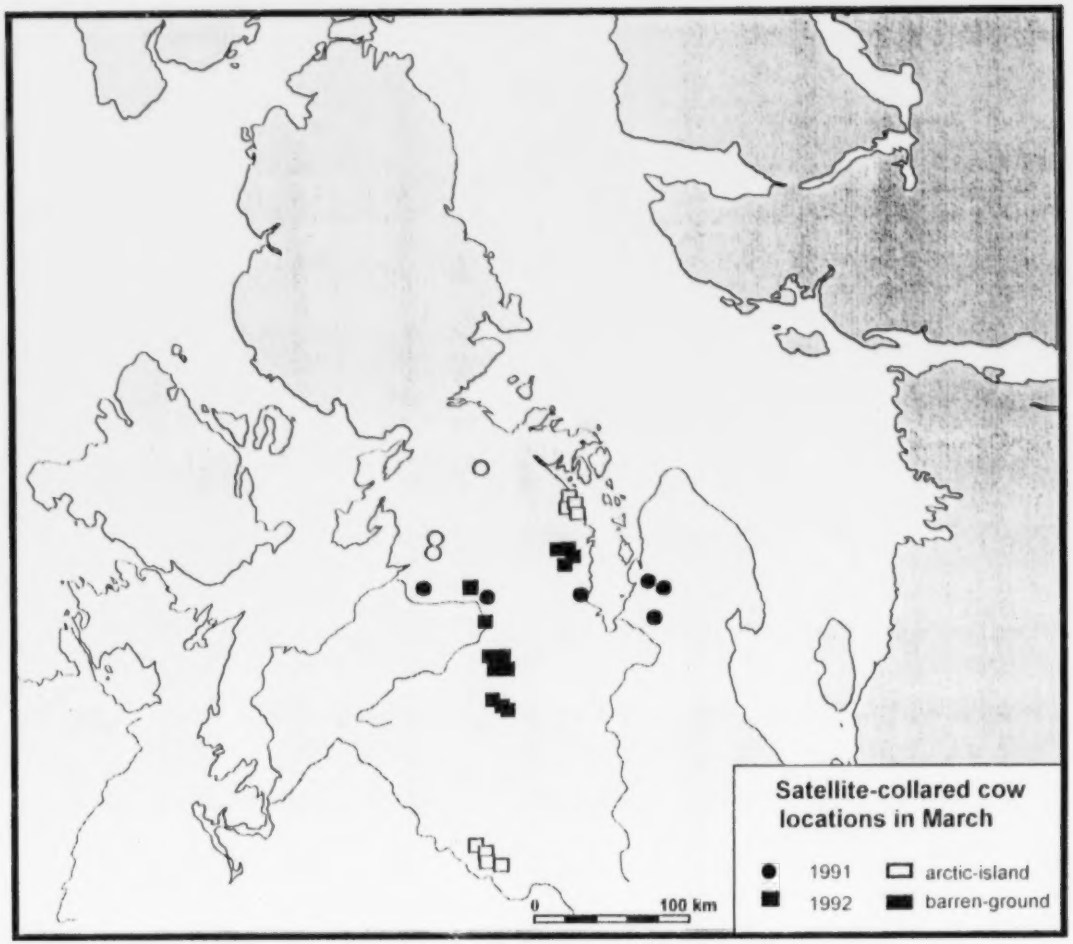


Figure 15. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for March 1991 and 1992.

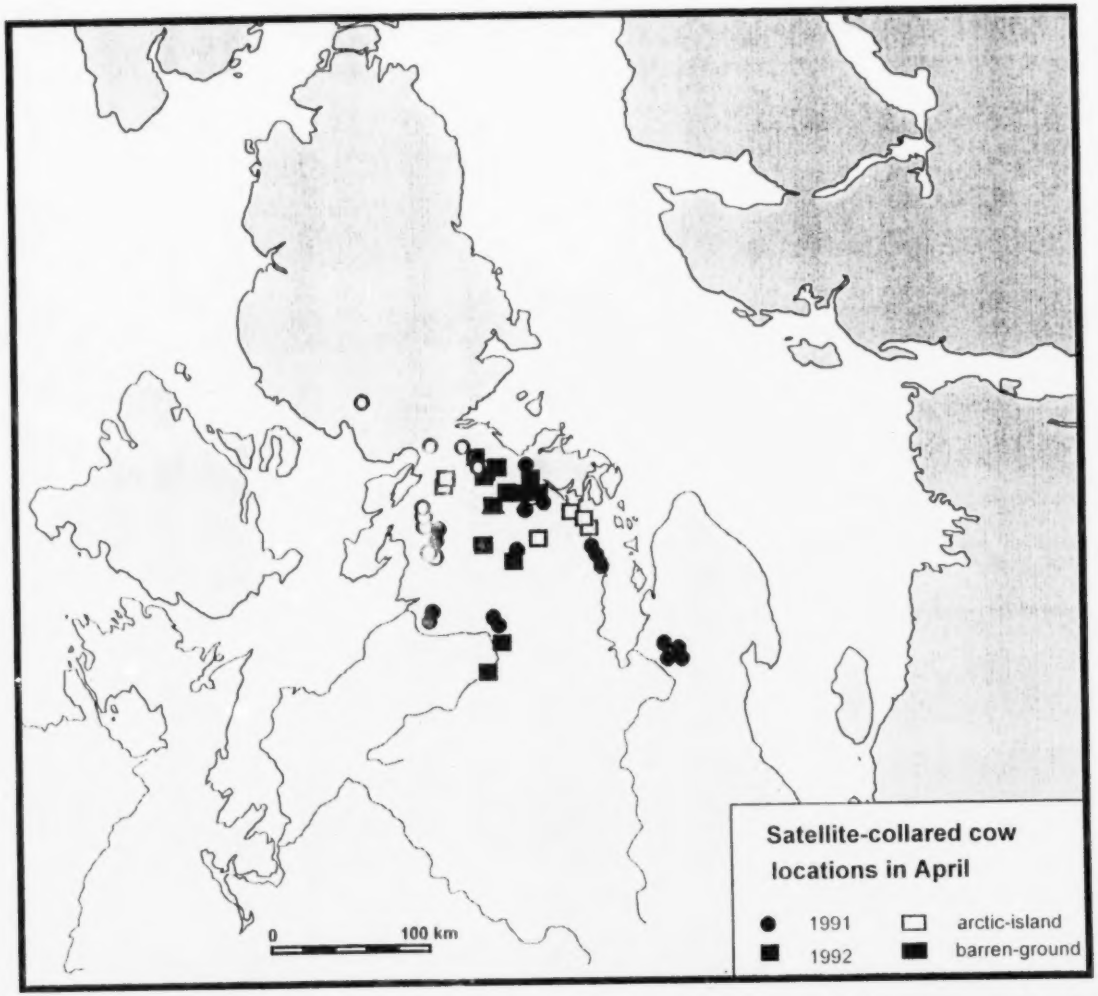


Figure 16. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for April 1991 and 1992.

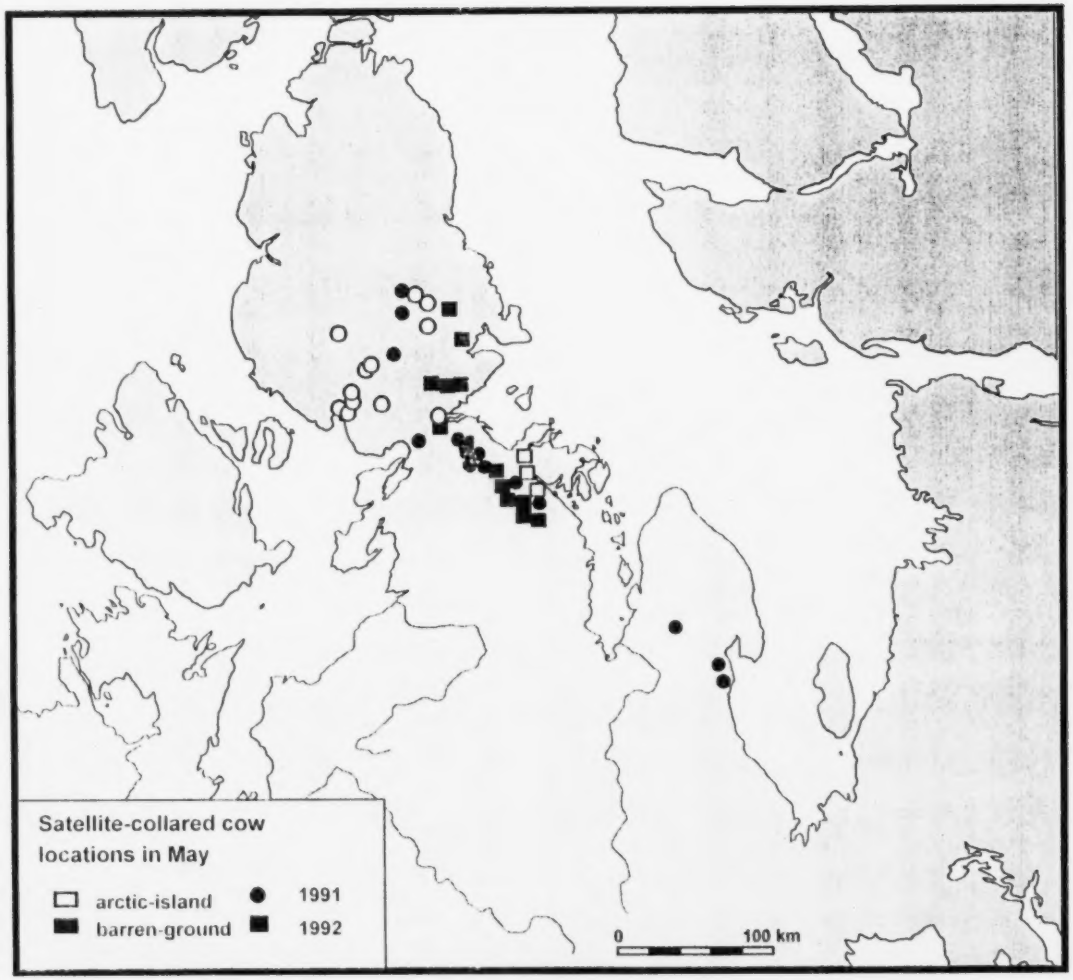


Figure 17. Satellite-collared caribou cow locations on Boothia and Simpson peninsulas for May 1991 and 1992.

The minimum straight-line distance traveled each month was greatest during September, October and November and again from late March to early June (Table 5). These time periods correspond to pre-calving movements and pre- and post-rut movements (Figures 6 -17). Minimum movement occurred during post-calving (late June and July) and winter (December, January and February).

Total distance moved monthly did not significantly differ between individuals (Table 5, Mann-Whitney Rank :H=9.9, 7 d.f. and P=0.1948). Annual movements of the four cows (with at least 16 months of location data) did not vary significantly between years (Table 6).

Table 5. Total monthly straight-line distance traveled (km) by collared cows on Boothia Peninsula in 1991 and 1992.

1991 Month	7760	7762	7765	7766	7767	7768	7769	7771
May	105	167	100	-	190	178	106	107
June	132	38	298	94	194	114	157	118
July	79	86	43	86	117	96	45	94
Aug	111	75	159	72	180	138	115	89
Sept	155	159	143	100	115	120	191	93
Oct	171	210	380	-	171	183	181	237
Nov.	96	138	178	-	199	102	171	119
Dec.	32	33	43	-	96	25	45	133
1992								
Jan.	74	32	41	-	81	57	49	-
Feb.	30	42	-	-	48	35	36	-
Mar.	41	29	-	-	158	34	-	-
April	76	57	-	-	126	159	-	-
May	133	155	-	-	127	166	-	-
June	102	196	-	-	91	108	-	-
July	82	104	-	-	485	135	-	-
Aug.	59	54	-	-	178	149	-	-
Sept.	177	-	-	-	219	107	-	-
Oct.	-	-	-	-	364	94	-	-

Table 6. Between-year comparison of daily distance traveled, May - September, between 1991 and 1992.

Collar #	Mann-Whitney Rank Sum comparison
7760	T=970 P=0.57
7762	T=826 P=0.99
7767	T=1069 P=0.2
7768	T=981 P=0.95

We calculated average distances to determine which cows were nearest each other during the rut and calving periods based on averaging distances between three locations during the rut (Oct 8, 18, 28) and three dates during calving (June 2, 15 and July 15). The arithmetic mean of the average calving and rut distances were calculated to show a relative distance between cows (Table 7). The table shows lower relative distances between the cows that used Boothia Peninsula and greater relative distance between these cows and the cows that used the Simpson Peninsula area. Another measure of association is shown by the cluster analysis of individual cow's annual movements (Figure 18). The distances measured between a fixed random point outside of the study area and each individual cow's location during calving and rut were compared using Pearson Product Moment correlation analysis and the correlation coefficient was graphed in a cluster analysis. The results show that the animals that used Boothia Peninsula clustered together, while the cows on and about Simpson Peninsula were separate and not closely related in their movements.

Table 7. Relative distances in km between satellite-collared cows calculated from distances between cows at calving and rut.

Mean distance in km between cows (SE) during calving and rut								
cow		7762	7765	7766	7767	7768	7769	7771
7760	calving	34 (13.2)	466 (37.2)	396 (7.3)	50 (4.3)	112 (2.8)	96 (3.3)	25 (9.1)
	rut	40 (14.5)	238 (12.1)	243 (18.0)	53 (10.6)	37 (11.9)	35 (7.8)	56 (15.1)
rel. distance		**36.7**	**352.3**	**319.3**	**51.3**	**74.3**	**65.6**	**40.6**
7762	calving	-	481 (26.1)	390 (10.1)	61 (5.0)	110 (4.2)	99 (3.1)	28 (12.5)
	rut	-	272 (22.8)	272 (4.2)	86 (16.2)	69 (7.9)	67 (11.8)	78 (20.3)
rel. distance			**376.3**	**330.7**	**73.5**	**89.2**	**82.8**	**52.7**
7765	calving	-	-	148 (6.3)	489 (36.1)	519 (29.5)	529 (34.1)	480 (33.6)
	rut	-	-	225 (16.3)	188 (8.3)	204 (16.0)	213 (20.5)	205 (20.7)
rel. distance				**186.3**	**338.4**	**361.3**	**370.6**	**342.5**
7766	calving	-	-	-	416 (16.6)	438 (14.8)	456 (8.3)	387 (9.7)
	rut	-	-	-	201 (7.8)	229 (8.5)	213 (11.9)	203 (5.1)
rel. distance					**308.8**	**333.4**	**334.3**	**295.2**
7767	calving	-	-	-	-	66 (3.2)	56 (5.1)	59 (3.6)
	rut	-	-	-	-	25 (8.3)	34 (6.9)	33 (13.3)
rel. distance						**45.5**	**45.1**	**46.4**
7768		-	-	-	-	-	30 (5.4)	118 (4.1)
	rut	-	-	-	-	-	30 (5.9)	40 (11.0)
rel. distance							**30.0**	**78.7**
7769	calving	-	-	-	-	-	-	108 (5.7)
	rut	-	-	-	-	-	-	51 (14.8)
rel. distance								**79.5**

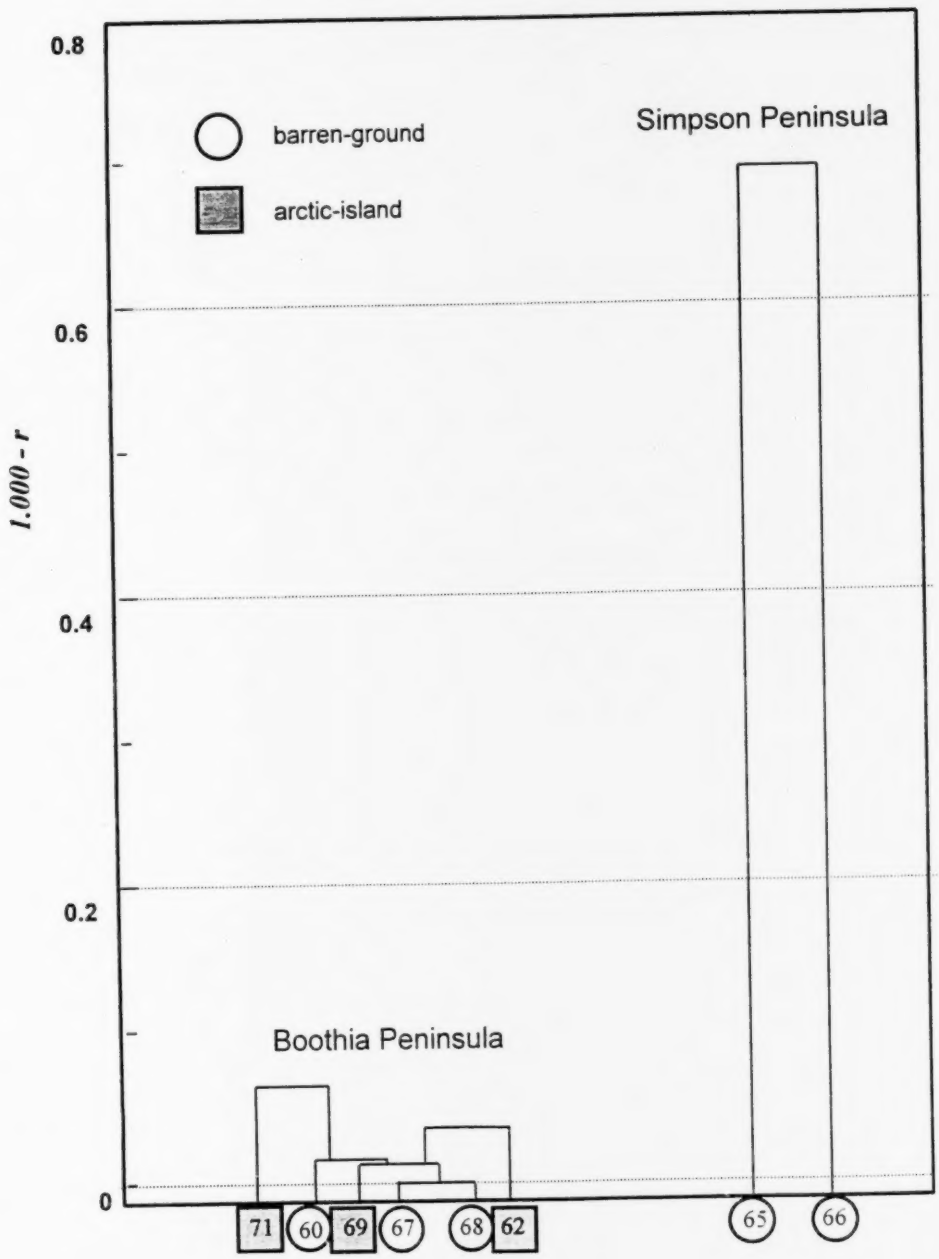


Figure 18. Cluster analysis of satellite-collared caribou cow annual movements relative to a fixed, random point outside the study area.

DISCUSSION

Data from the satellite collars suggests that caribou wintering around Pelly Bay in 1991 based on calving distribution could be assigned to three herds (Simpson Peninsula, Keith Bay and south Melville Peninsula) including the previously described south Melville herd (Heard *et al.* 1987). However, we recognize the provisional nature of any assignments given the sample size (three cows). However, each of those cows calved where there were other calving cows, and for Simpson Peninsula and south Melville Peninsula there is a history of calving in those areas (Gunn and Fournier 2000a). Two of the three cows also rutted in distinct areas – cow 7766 rutted on Simpson Peninsula and cow 7765, which had moved to south Melville Peninsula in June, rutted west of Simpson Peninsula on the Hayes River. The third cow's distribution during the rut is unknown as her satellite transmitter failed in June 1991.

During the satellite-collaring south of Boothia Peninsula, we collared both arctic island caribou (similar in appearance to Prince of Wales and Somerset caribou) and barren-ground caribou. Assignment of the caribou to two herds is tentative, as although the two types of caribou had two calving areas, the areas were adjacent and the rutting distribution was not clearly geographically separate. However, we might not expect geographic separation as the rut occurred where Boothia Peninsula narrows, creating a funnel as the animals travel south toward wintering areas. We suspect that the timing of the peak of the rut in the barren-ground and arctic-island caribou may not have coincided. The resolution of timing is limited to 5-day averages as the satellite collars only transmitted every 5 days and the number of collars is low. However, inspection of the activity data and distances travelled (Appendix C) suggested that rutting in the barren-ground caribou may have peaked a few days later than the arctic-island cows.

In June, the six satellite-collared cows were on northwestern Boothia Peninsula, with the two of the three arctic-island cows seen with calves in 1991 between Wrottesley Inlet and Pasley Bay and two of three barren-ground cows either pregnant or seen with a calf further east toward the northeast coast in 1991, 1992 and 1993. Cow 7767 was on the central Boothia Peninsula in June 1991 and 1993 when she was not pregnant.

The calving area on Boothia Peninsula south of Wrottesley Inlet was identified in the 1970s (Fischer and Duncan 1976, Fischer *et al.* 1977) and again in 1985 (Gunn and Ashevak 1990). In late June and early July 1975, many caribou were still concentrated in the extreme northwest of Boothia Peninsula, but numbers of bulls and sub-adults were also observed in the north-central portion of the Peninsula. During the 1985 survey we did not consistently distinguish between arctic-island and barren-ground caribou. However, we noted smaller numbers of barren-ground caribou with calves on northeast Boothia Peninsula in June 1985 (Gunn and Ashevak 1990).

Earlier accounts of caribou sightings on the Boothia Peninsula identify both barren-ground and *pearyi* – type (Manning and Macpherson 1962). Subsequently, in 1976 and 1977, caribou collected on northern Boothia Peninsula were similar but slightly larger than caribou from Prince of Wales and Somerset, except for one young bull that was more typical of barren-ground caribou and one cow that was more similar to Prince of Wales-Somerset (Thomas and Everson 1982). The caribou cows taken on central Boothia Peninsula were predominantly barren-ground caribou being larger, longer-legged and having conspicuously dark pelage. In the 1980s, hunters report two types of caribou in the same social groups during the winter (David Tucktoo pers. comm. 1986).

Thomas and Everson (1982) also refer to several sub-populations of caribou on Boothia Peninsula, Prince of Wales and Somerset islands, although without specifying whether 'sub-population' referred to the morphologically distinctive types. The use of terms herd, population and sub-population varies between publications; in this report we equate herd with population and so we use population as explained in the following paragraphs.

Herds and populations are terms that have slipped into being used interchangeably, but in the earlier caribou literature a population constituted several herds (Thomas 1969). The herds were caribou that wintered in different areas but ear-tagging studies and aerial surveys had shown that caribou from several herds (winter ranges) would return to specific calving grounds. Thomas (1969) identified four populations of mainland barren-ground populations (Bluenose, Bathurst, Beverly and Kaminuriak) based on their return to calving grounds and that those populations were composed of 11 herds. However, over the subsequent years and perhaps reflecting popular use, 'herd' has replaced 'population'.

We have followed convention in assigning herd identity based on fidelity to calving grounds for barren-ground caribou regardless of whether they winter on the tundra or taiga grounds (Thomas 1969, Gunn and Miller 1986, Heard and Stenhouse 1992). We recognize that using return to the calving grounds as a spatial definition only partially meets the definition of a population. Populations are groups of conspecific individuals that are demographically, genetically or spatially distinct from other groups of individuals (Wells and Richmond 1995).

We interpret Wells and Richmond's (1995) use of the term 'spatially disjunct' to mean the geographic distribution of individuals with no connotation of 'static geographic areas', which was Ferguson and Messier's (2000) interpretation of Wells and Richmond's (1995). When we define herds on the basis of their

annual return to calving grounds, we are not implying that calving grounds are fixed geographic entities. Even although calving distribution overlaps between years, over decades there is rotational shifting for at least some calving grounds (Sutherland and Gunn 1996, Gunn and Sutherland 1997).

Elders in Pelly Bay identified the Simpson Peninsula as a calving ground (Charlie Niptayok pers. comm. 1987) which was also the area used by one of the satellite-collared cows. Bernart Iqquguarktuk reported that his father used to see caribou calving on the area southeast of Lord Mayor Bay, which is similar to the area Manning (n.d.) also identified. Levy Itluittuq and Otto Apsaktaun both reported calving west of Pelly Bay near the hills south Simpson Lake. The collared cows did not use that area but in 19885 and 1989, we recorded calving in that area (Gunn and Fournier 2000a). Those observations suggest that the use of at least some of the areas for calving has persisted for years.

Support for using the annual return to traditional calving grounds as the basis for defining caribou herds has come from using satellite telemetry and nuclear DNA analyses. Ongoing research indicates that, at least for the mainland Bluenose and Bathurst caribou and the Dolphin and Union caribou on Victoria Island, caribou that calve together, rut together and this is reflected in greater genetic similarity than with neighboring caribou (J. Nagy and K. Zittlau unpubl. data, Gunn and Fournier 2000b, Gunn and Dragon unpubl. data). However, for Peary caribou (*R. t. pearyi*) in the High Arctic on Bathurst and its satellite islands, genetic structuring did not coincide with structuring based on rutting and calving distributions (Zittlau *et al.* 1999) possibly because the caribou numbers have fluctuated with at least one recorded decline of over 90% between 1961 and 1994 (Miller *et al.* 1977).

We would be imprudent to assume rigid definitions will apply for all caribou populations. Caribou across their circumpolar distribution are diverse. Caribou

numbers can fluctuate tenfold over decades and correspondingly their ranges contract and expand. As our experience with the fluctuations in numbers and range use increases, so does our understanding of caribou dynamics and ecology. Most caribou biologists would agree with Ferguson and Messier's (2000) description of how Inuit apparently view caribou populations, which is that caribou populations are biological units that use space in an adaptive manner over several decades. For example, Russell *et al.* (1993) describe how the Porcupine herd has rotational shifts of winter ranges (1970-89) reflecting snow conditions and traditional behaviour. The caribou had affinity for certain winter ranges but that behaviour was modified if snow conditions departed from the normal.

Caribou distribution has changed over decades in the area of Boothia Peninsula and Pelly Bay. Most published information is for the Boothia Peninsula and records a disappearance of caribou from the Boothia Peninsula by the 1930s. Those caribou used to move north to calve on the coastal high ground between Thom Bay and Lord Mayor Bay (Macpherson n.d., Freeman 1976). After calving, the caribou summered on the Boothia Isthmus and winter range was similar extended some 50 km south (Freeman 1976). Between the 1950s and 1970s, the caribou's use of winter range contracted to the north of the Boothia Isthmus.

In the mid-1970s, the wintering areas were the northeast uplands and coastal plain south to Thom Bay. In March 1975 and 1976, caribou were mostly on northeast Boothia (Cape Nordenskiold area) where the distribution of winter fecal pellets identified beach ridges as important winter ranges (Russell *et al.* 1976). No winter pellets were found at about 20 sites in the Boothia Isthmus (Russell *et al.* 1976).

Aerial surveys in the 1970s (Fischer and Duncan 1976) documented caribou wintering north of Taloyoak, but during the 1980s hunters reported caribou closer to the community, and in the late 1980s caribou were migrating in the fall to winter south of Taloyoak. This suggests that the movement of caribou from north and south of the Isthmus to winter in the area south and west of Thom Bay to Netsilik Lake in the 1980s is thus relatively recent and a resumption of the historic movements.

We only had information on early to late winter distribution for 1991/92 winter but it suggested that the caribou are extending their wintering areas further south of the Boothia Isthmus. The movements, however, of cow 7767 moving south almost to Baker Lake in November 1992 was unexpected and we cannot determine if the movement was individual variation or an abrupt shift in winter distribution as we do not know the distribution of the other caribou. Out of the three cows collared in April 1991 near Pelly Bay, we only have winter distribution for cow 7765, and her seasonal pattern of movements tended to be east-west. She wintered in a similar area to those cows that calved and summered on Boothia Peninsula.

Overlap in winter ranges is common for caribou and extension and shifts in winter range – expansion and contraction as numbers increase and decrease – is also common, if not a characteristic of caribou (for example, Fleischman 1990). To describe changes in winter range, we use the terms extension and abrupt shift to distinguish between the iterative movements (expansion) of range use (extension) and the abrupt shifts with movement to a range spatially separate and not overlapping with the preceding year. We use shift as defined to change place or direction - (Webster's New Collegiate Dictionary 1975).

Thomas and Everson (1982) suggested that in the mid-1970s, caribou movements between the islands annually varied between Boothia Peninsula,

Prince of Wales and Somerset Islands. Inuit local knowledge, seasonal differences in caribou numbers during aerial surveys and track counts on the sea-ice in late winter and spring suggested that caribou were moving from Boothia Peninsula to Somerset and to Prince of Wales to calve and summer (Freeman 1976). In June 1978, we counted tracks for at least 158 caribou moving across the sea-ice from Boothia to Prince of Wales, and in May-June 1979, 37 tracks were heading west from Boothia and 28 tracks from Prince of Wales to Boothia Peninsula (Miller *et al.* 1982).

None of the satellite-collared caribou on the Boothia Peninsula moved north off the Peninsula between 1991 and 1993. However we cannot discriminate between a change in migratory behavior or the decline of the caribou that, in the 1970s, migrated between Boothia Peninsula, Prince of Wales and Somerset islands. By the mid-1990s, caribou numbers on Prince of Wales and Somerset island had declined from 6000 in 1980 to less than a 100 in 1995 (Gunn and Dragon 1998). On Boothia Peninsula, numbers were not surveyed in 1980, but surveyed in 1985 and 1995 (Gunn and Ashevak 1990, Gunn and Dragon 1998). Between 1985 and 1995, the estimates of caribou numbers were not significantly different - 6658 $\pm$ 1728 SE (1995) and 4831 $\pm$ 543 SE (1985).

The satellite collars were operational for too brief a time period for us to describe fidelity to specific ranges on one hand and shifts over time on the other hand. However previous aerial surveys and information from hunters suggests that winter ranges have expanded during the 1980s and early 1990s but that there is fidelity to calving grounds.

Our results tentatively identify five herds of caribou wintering in the vicinity of Taloyoak and Pelly Bay in the early 1990s even though we recognise that the results are based on a low number of satellite collars over a short interval of time. The two herds on west and east Boothia Peninsula were arctic-island

caribou and barren-ground caribou, respectively, which raises interesting questions about maintenance of diversity in caribou.

The conventional model of caribou numbers fluctuating over decades (Caughley and Gunn 1993) with contraction and then expansion and re-colonisation of ranges could be expected to decrease gene flow if expansion and re-colonisation led to caribou ranges overlapping or emigration. And, in theory, it only takes a handful of dispersing individuals to reduce the effects of spatial segregation on gene flow (assuming the individuals successfully reproduce).

However, evidence suggests that herd (population) structure is maintained during the fluctuations in numbers. Although our knowledge of the genetic structure of caribou populations is incomplete, there are genetic differences between barren-ground, arctic-island and woodland herds that have been examined so far (K. Zittlau pers. comm.), which also indicates the persistence of herd structure. Our results suggest the persistence of arctic-island and barren-ground caribou despite adjacent seasonal ranges on the Boothia Peninsula, which is further evidence that genetic diversity is maintained despite fluctuations in numbers and range use at least over decades.

ACKNOWLEDGEMENTS

We thank Paul Fraser (Department of Renewable Resources) and Mike McNeill (Sunrise Helicopters) for their help capturing the caribou. Perry Linton (Northwright Air) ably demonstrated his flying skills and we thank Ovide Alakannuak, Sandy Buchan, David Igutsaq as observers and George Tootaluk for help in collecting the caribou. We thank Charlie Niptayok for sharing information from elders and for assistance during the study. Ray Bethke drafted maps and analyzed data. We also thank the Department of Sustainable Development, Government of Nunavut, for providing the funding to complete the production of this report.

PERSONAL COMMUNICATIONS

Otto Apsaktaun, Pelly Bay, NT

Bernart Iqquguarktuk, Pelly Bay, NT

Levy Itluittuq, Pelly Bay, NT

K. Kittlau, Department of Genetics, University of Alberta, Edmonton, Alberta

Charlie Niptayok, Pelly Bay, NT

D. Tucktoo, President, Hunters' & Trappers' Association, Taloyoak, NT

REFERENCES

Caughley, G. and A. Gunn. 1993. Dynamics of large herbivores in deserts: kangaroos and caribou. Oikos 67: 47-55.

Fancy, S. G., L. F. Pank, K. R. Whitten and W. L.Regelin. 1989. Seasonal movements of caribou in arctic Alaska as determined by satellite. Canadian Journal of Zoology 67: 644-650.

Ferguson, M. A. D. and F. Messier. 2000. Mass emigration of arctic tundra from a traditional winter range: population dynamics and physical condition. J. Wildl. Manage. 64: 168-175.

Fischer, C.A. and E.A. Duncan. 1976. Ecological studies of caribou and muskoxen in the Arctic Archipelago and northern Keewatin, 1975. Report prepared for Polargas Environmental Program by Renewable Resources Consulting Services Ltd. 194 pp.

Fischer, C.A., D.C. Thompson, R.L. Wooley, and P.S. Thompson. 1977. Ecological studies of caribou on the Boothia Peninsula and in the district of Keewatin, NWT, 1976. Report prepared for Polargas Environmental Program by Renewable Resources Consulting Services Ltd. 239 pp.

Fleischman, S.J. 1990. Lichen availability on the range of an expanding caribou (*Rangifer tarandus*) population in Alaska. MS thesis, University of Alaska, Fairbanks Alaska, 81pp.

Freeman, M.M.R. 1976. Inuit land use and occupancy project. Indian and Northern Affairs Canada, Ottawa, Ontario. Vol. I, 262 pp.

Gunn, A. and J. Ashevak. 1990. Distribution, abundance and history of caribou and muskoxen north and south of the Boothia Isthmus, NWT, May-June 1985. Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories. File Rep. No 90. 34 pp.

Gunn, A. and J. Dragon. 1998. Abundance and distribution of caribou and muskoxen on Prince of Wales and Somerset islands and Boothia Peninsula, 1995, NWT . Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories. File Rep. No122, 47pp.

Gunn, A. and B. Fournier. 2000a. Identification and substantiation of caribou calving grounds on the NWT mainland and islands . Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories. File Rep. No. 123. 177 pp.

Gunn, A. and B. Fournier. 2000b. Caribou herd delimitation and seasonal movements on Victoria Island 1987-89 Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories. File Rep. No. 125. 104 pp.

Gunn, A. and F. L. Miller. 1986. Traditional behaviour and fidelity to calving grounds by barren-ground caribou. Rangifer Special Issue No. 1: 151 - 158.

Gunn, A. and M. Sutherland. 1997. Surveys of the Beverly caribou calving grounds, 1957-1994. Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories. File Rep. No. 120. 119 pp.

Heard, D.C., T.M. Williams and K. Jingfors. 1987. Pre-calving distribution and abundance of barren-ground caribou on the northeastern mainland of the Northwest Territories. Department of Renewable Resources, Government of the Northwest Territories. File Report 71. 28 pp.

Heard, D.C. and G.B. Stenhouse. 1992. Herd identity and calving ground fidelity of caribou in the Keewatin District of the Northwest Territories. Department of Renewable Resources, Government of the Northwest Territories. File Report No. 101. 34 pp

Macpherson, A.H. n.d. The caribou of Boothia Peninsula. Unpublished report, Canadian Wildlife Service, Ottawa, Ontario. 16 pp.

Manning, T.H. and A. H. Macpherson. 1962. A biological investigation of Prince of Wales Island, N.W.T. Trans. Royal Canadian Institute 33. 239 pp. Arctic Institute North America Technical Paper No. 4. 52 pp.

Merriam Company, G. and C. 1975. Webster's New Collegiate Dictionary Springfield, Massachusetts.

Miller, F.L., R.H. Russell, and A. Gunn. 1977. Distributions, movements and numbers of Peary caribou and muskoxen on western Queen Elizabeth Islands. Canadian Wildlife Service Report Series No. 40. 55 pp.

Miller, F.L., E.J. Edmonds and A. Gunn. 1982. Foraging behaviour of Peary caribou in response to springtime snow and ice conditions. Canadian Wildlife Service, Occas. Pap. No. 48. 41 pp.

Russell, R.H., E.J. Edmonds and J. Roland. 1976 Caribou and muskoxen habitat studies. Environmental Social Program, Northern Pipelines, ESCOM Report No. A1-26. 40 pp.

Russell, D. R., A. M. Martell and W. Nixon. 1993. Range ecology of the Porcupine Caribou Herd in Canada. Rangifer Special Issue 8. 168pp

Sutherland, M. and A. Gunn. 1996. Bathurst calving ground surveys, 1965-1996. Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories. File Report No. 118. 97 pp.

Thomas, D.C. 1969. Population estimates and distribution of barren-ground caribou in Mackenzie District, NWT, Saskatchewan and Alberta - March to May 1967. Canadian Wildlife Service Report Series No. 9. 44 pp.

Thomas, D.C. and P. Everson. 1982. Geographic variation in caribou on the Canadian arctic islands. Can. J. Zool. 60(10):2442-2454.

Wells, J. V. and M. E. Richmond. 1995. Populations, metapopulations, and species populations: what are they and who should care? Wildlife Society Bulletin 23:458-462.

Zittlau, K. A. Gunn, F. L. Miller and C. Strobeck. 1999. Genetic relatedness and diversity in Peary caribou (*Rangifer tarandus pearyi*) from the Bathurst Island complex. Poster presented at International Arctic Ungulate Symposium, Tromso, Norway

Appendix A. Description of cows fitted with satellite-collars, March 1991

25 March 1991 - Pelly Bay area – south of Barrow Lake; groups of 20-30 barren-ground caribou, mostly cow and calf groups.

Cow 7766 – 68°31' N 89°42' W
Large angular barren-ground cow; flattened incisors; shedding winter hair on neck.

Cow 7764 - 68°31' N 89°42' W
Smaller barren-ground cow with calf; little wear on incisors; shedding winter hair on neck.

25 March 1991 – West coast Pelly Bay – scattered groups

Cow 7765 - 68°15' N 89°25 'W
Medium-sized barren-ground cow with calf; slight wear incisors; face shedding winter hair; good shape.

Cow 7767 - 68°42' N 90°41' W
Smaller-sized barren-ground cow with calf; deciduous canines ;

26 March – Shepherd Bay area – scattered groups of arctic-island caribou with few barren-ground caribou in same groups – most <5 caribou/group.

Cow 7762 - 68°52' N 90°20' W
Arctic-island caribou; longish white head, grey back , white legs and no dark brown; slight wear incisors; good shape.

Cow 7771 - 68°50' N 90°20' W west of Melville Lake
Arctic-island caribou; longish white head, grey back , white legs and no dark brown; deciduous canines; thin; in group of 4 cows,a young bull and three calves.

Cow 7769 - 69°18' N 92°37' W
Arctic-island caribou; longish white head slightly mottled grey-brown above muzzle grey back , white legs and no dark brown; slight wear incisors; group of 7 arctic-island cows.

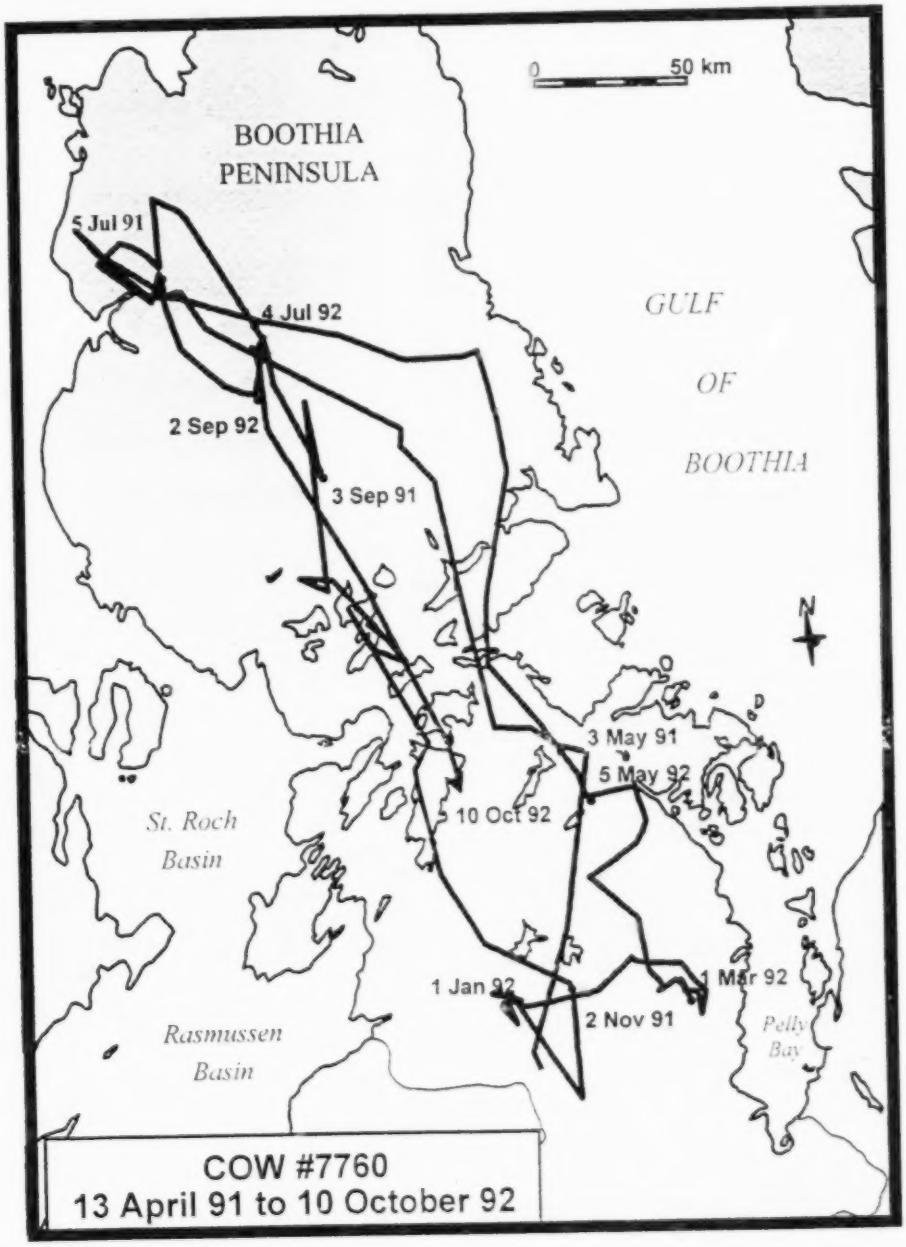
Appendix A (cont'd)

27 March – Simpson Lake to Murcheson Lake – scattered groups of barren-ground caribou – bulls near Simpson Lake and cows south of Inglis River

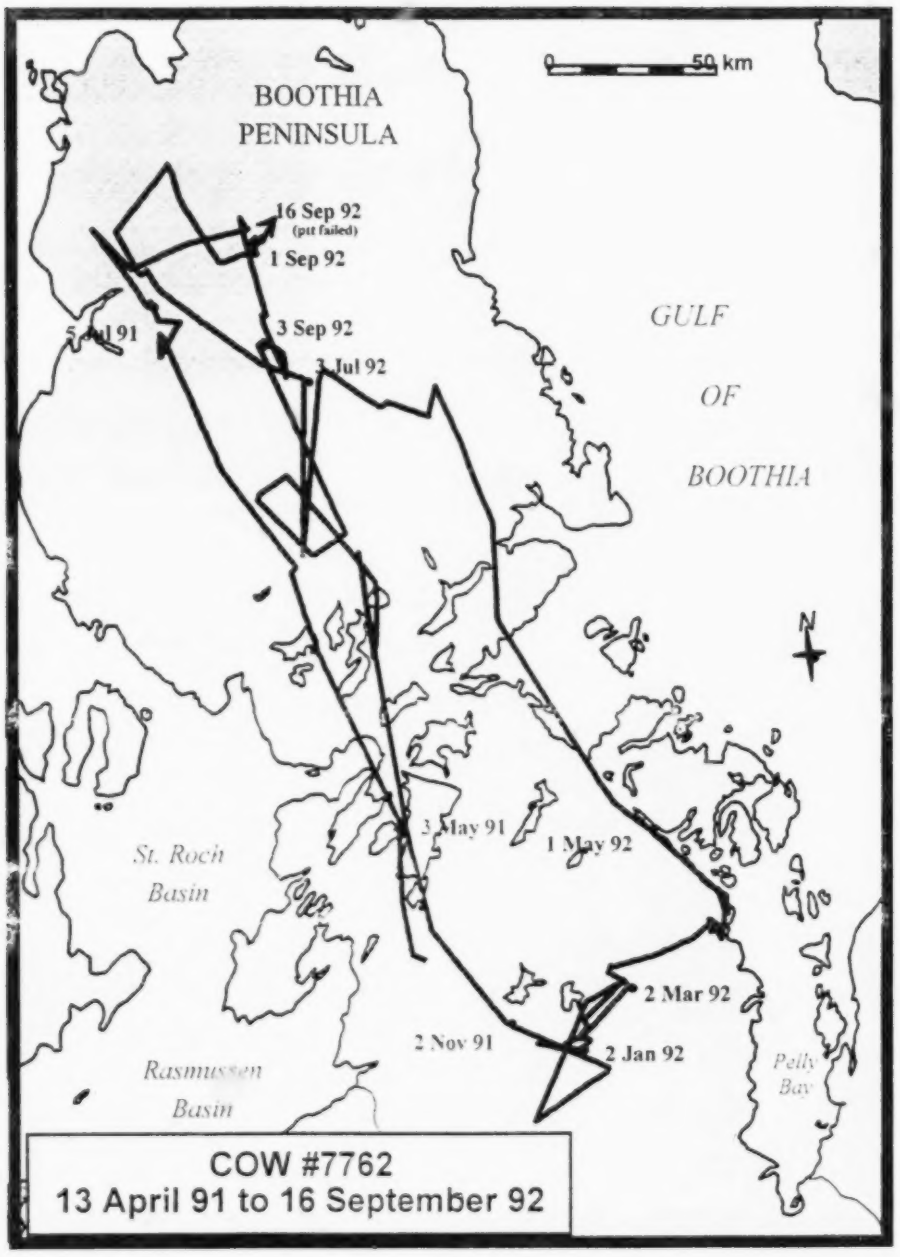
Cow 7760
Barren-ground cow; moderate wear incisors; with calf, yearling and 4 cows; thin

Cow 7768
Barren-ground cow; moderate wear incisors; with calf, and 15 cows and calves; thin

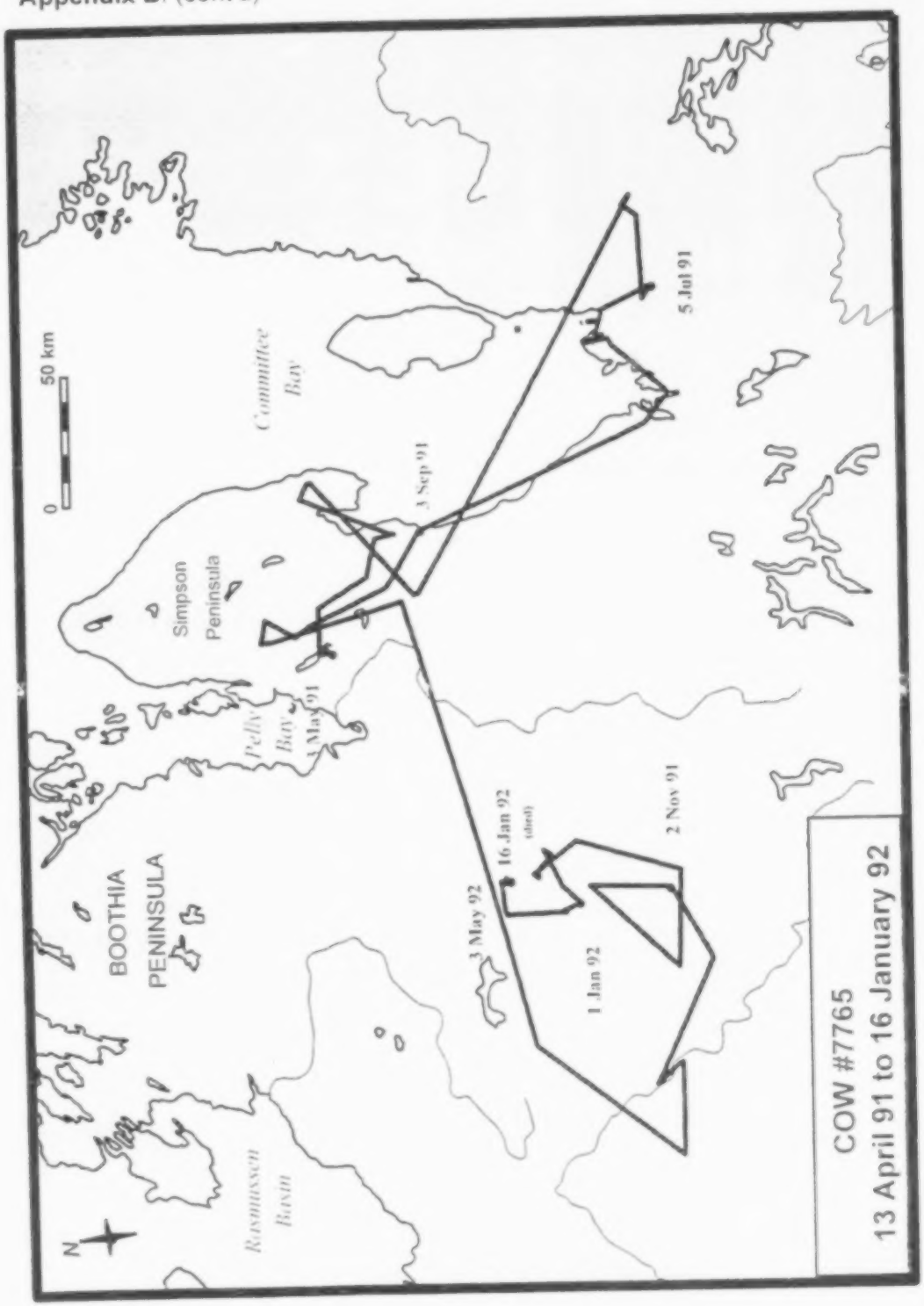
Appendix B. Maps of individual movements for satellite-collared caribou on Boothia and Simpson peninsulas, 1991 and 1992



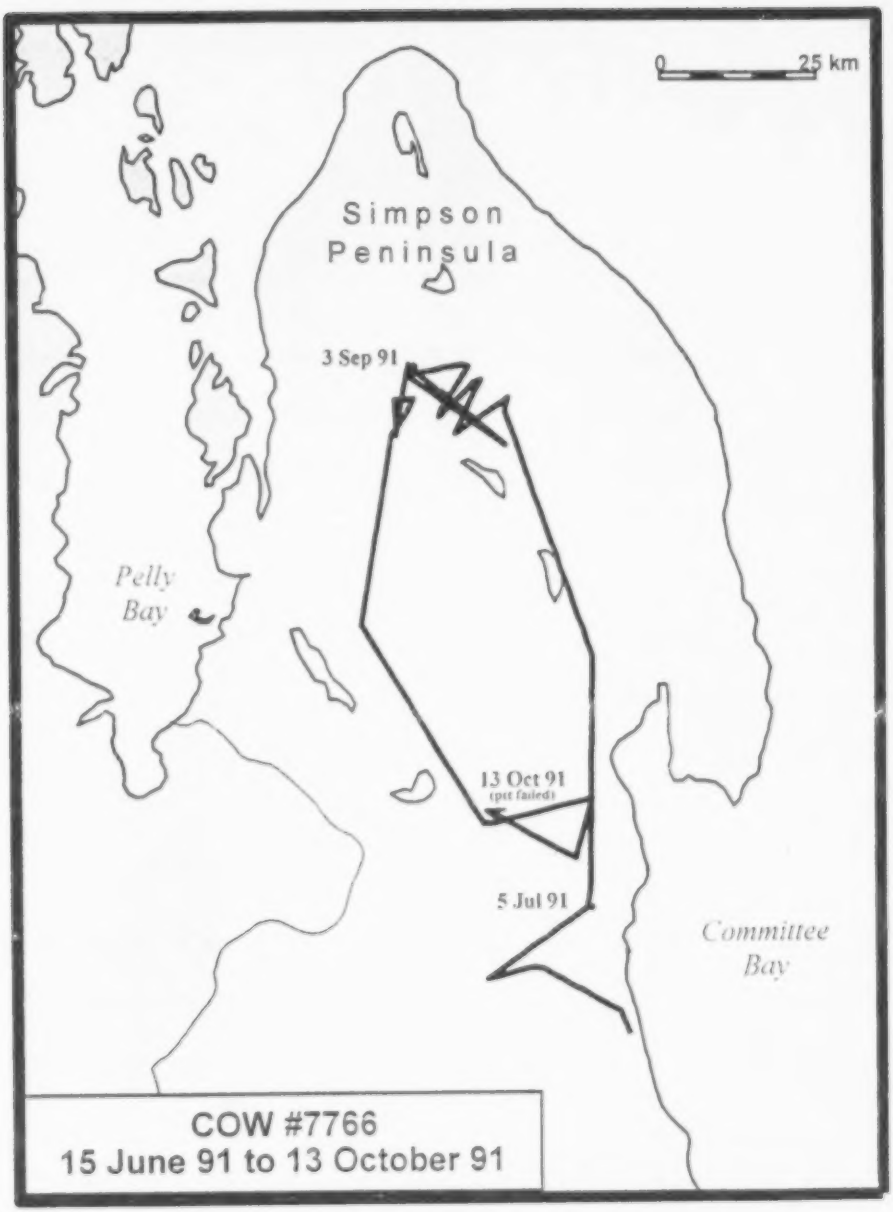
Appendix B. (cont'd)



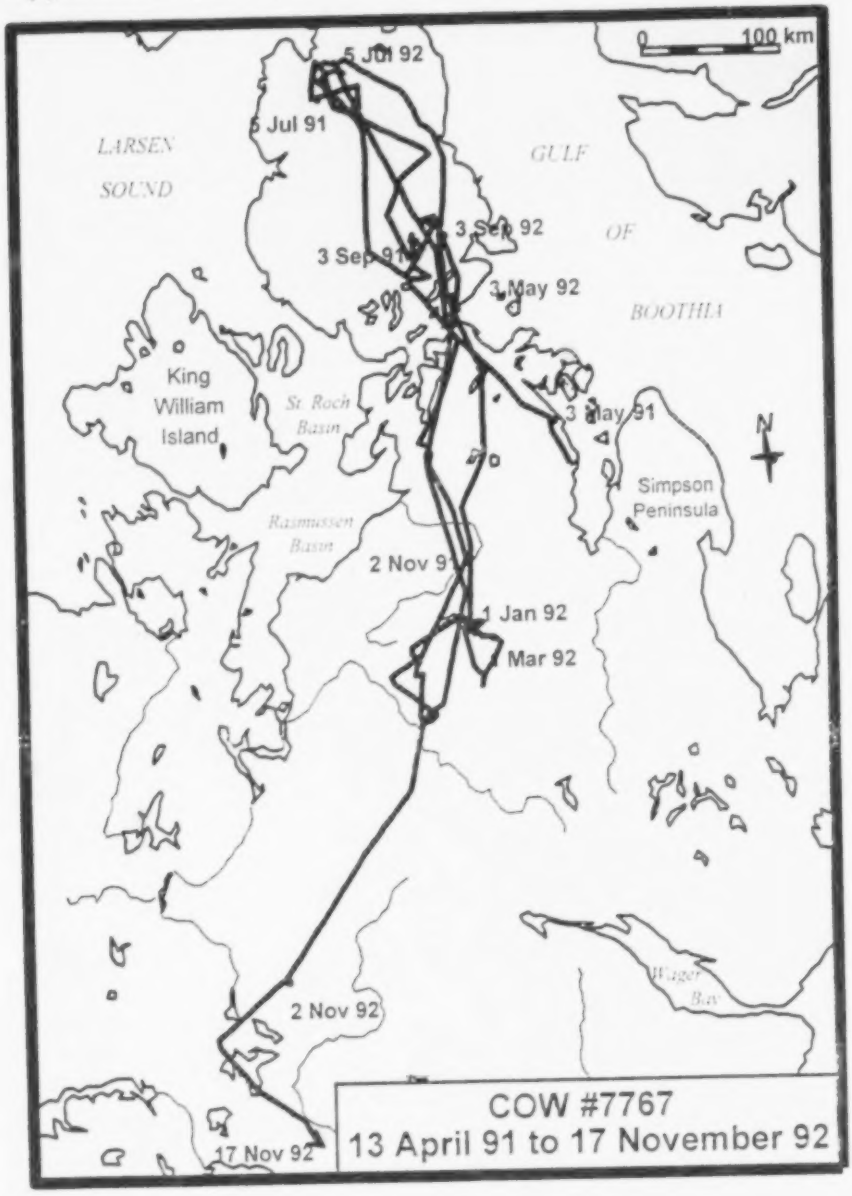
Appendix B. (cont'd)



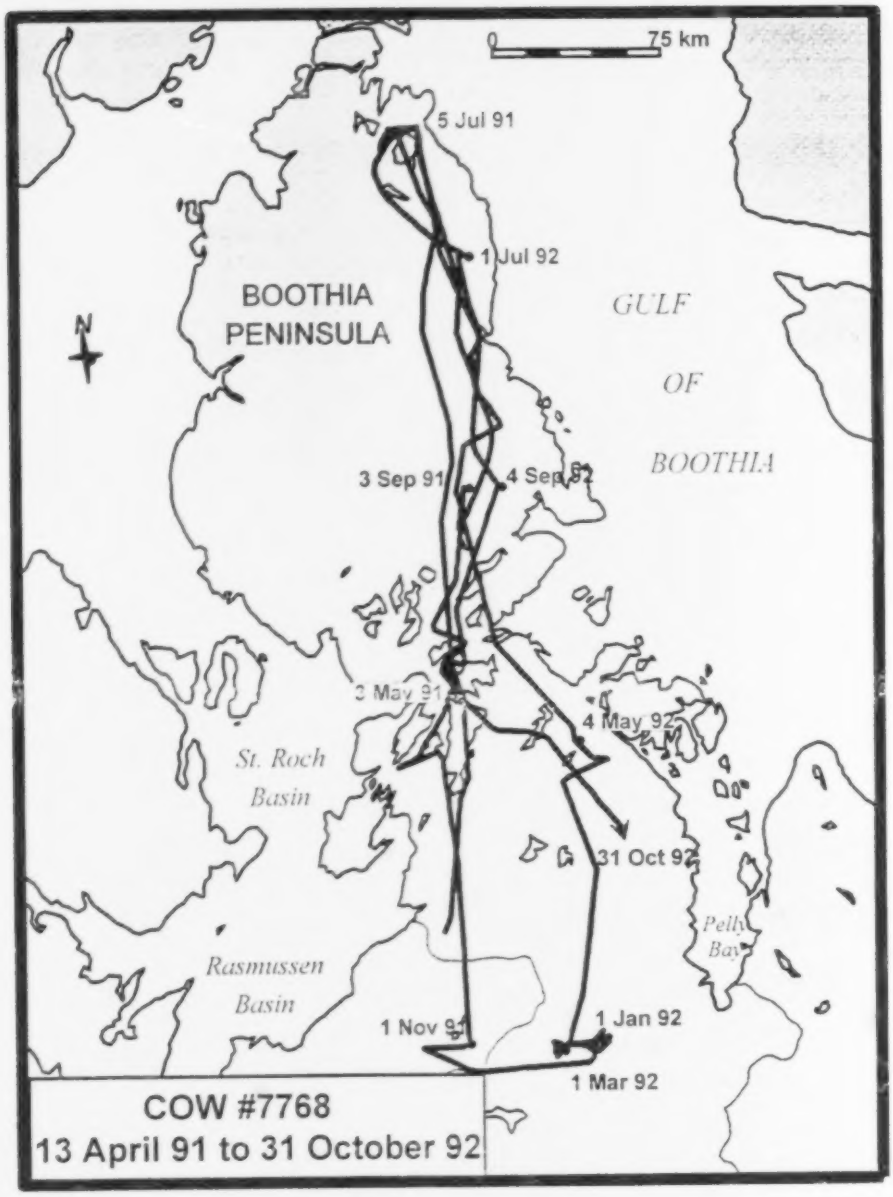
Appendix B. (cont'd)



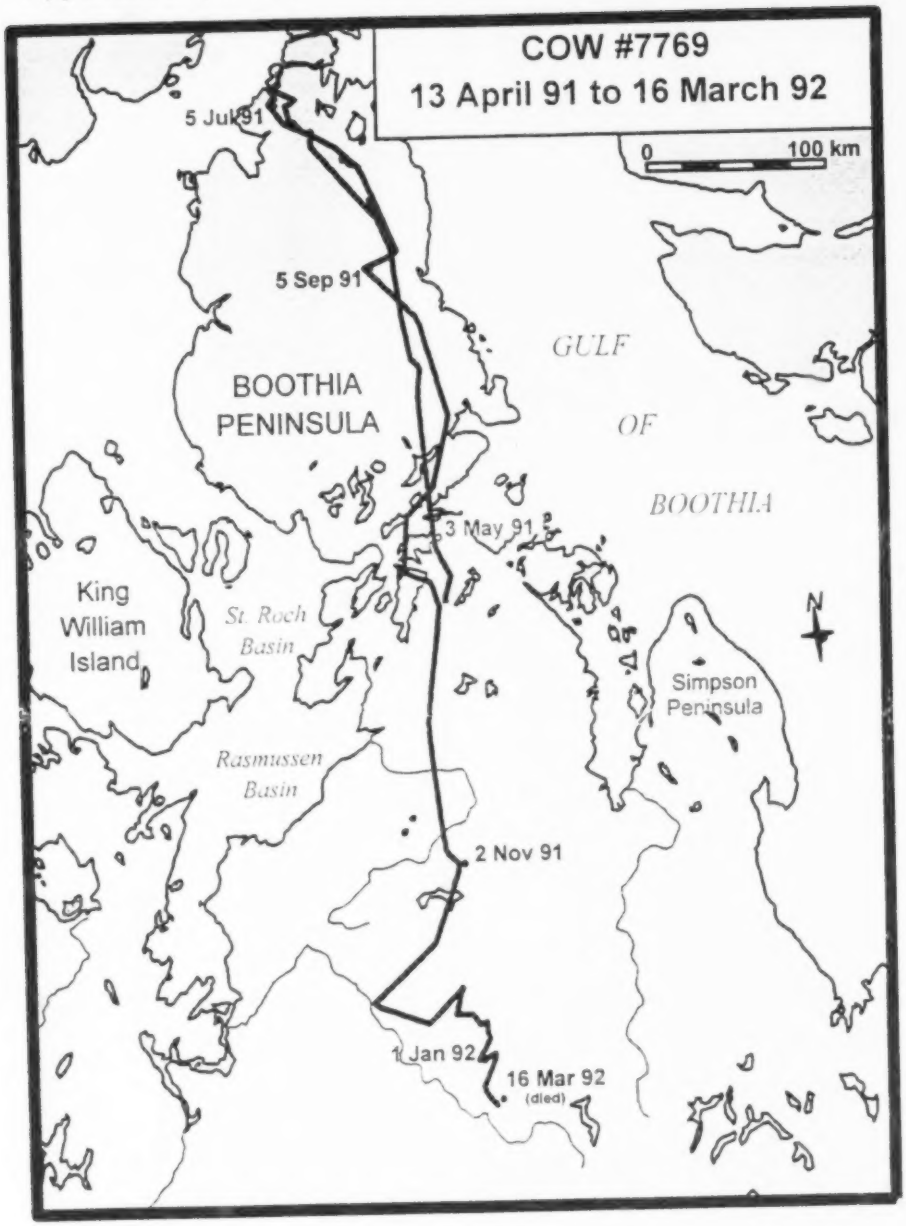
Appendix B. (cont'd)



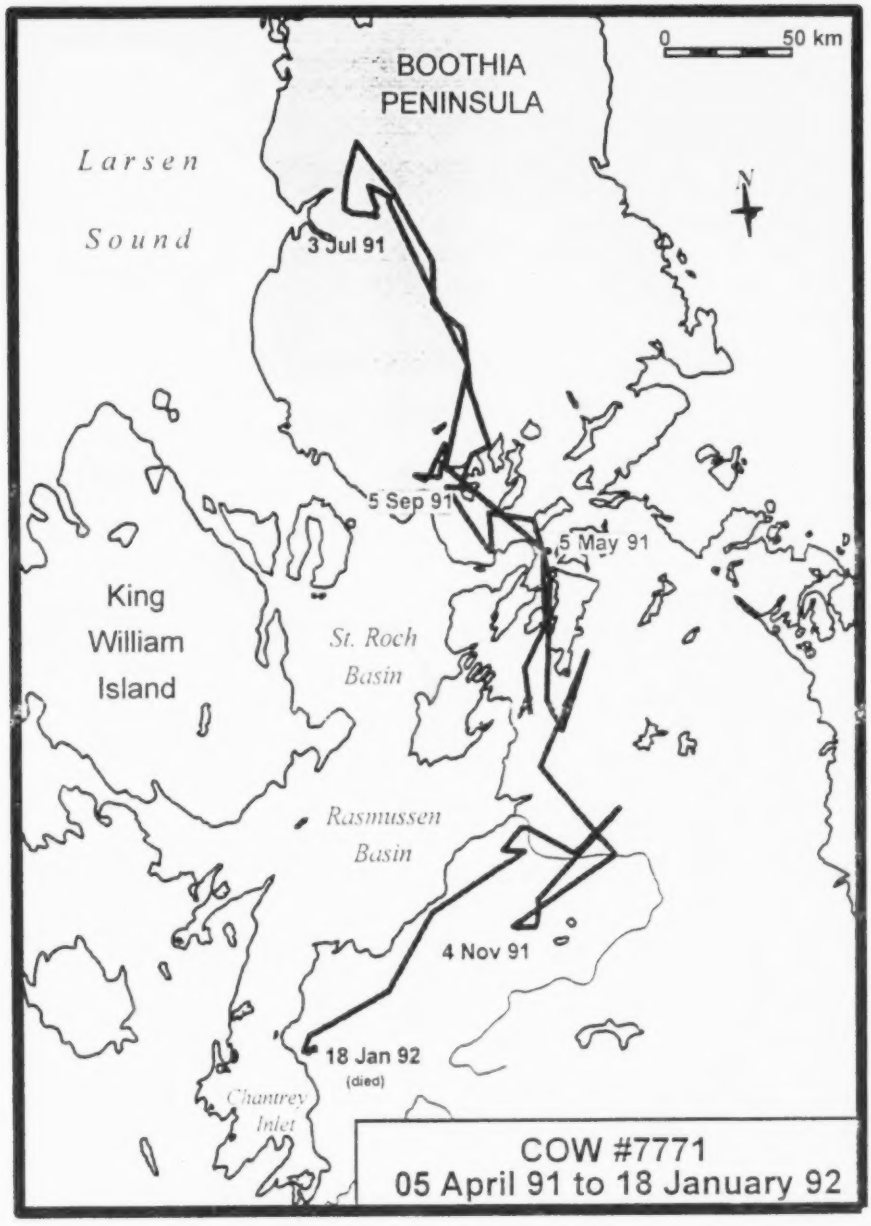
Appendix B. (cont'd)



Appendix B. (cont'd)



Appendix B. (cont'd)



Appendix C. Location data and distance traveled for satellite-collared caribou cows on Boothia Peninsula, 1991-93.

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7760	13APR91	6828	9209	88	-	-
7760	18APR91	6831	9213	81	8.43	42.2
7760	23APR91	6853	9157	263	11.55	57.8
7760	28APR91	6924	9148	214	2.00	9.9
7760	03MAY91	6925	9203	171	2.02	10.1
7760	08MAY91	6928	9216	146	2.47	12.4
7760	13MAY91	6928	9235	188	0.00	0.0
7760	18MAY91	6928	9235	95	1.92	9.6
7760	23MAY91	6933	9239	124	6.55	32.8
7760	28MAY91	6950	9253	213	8.04	40.2
7760	02JUN91	7011	9309	69	5.43	27.2
7760	05JUN91	7017	9328	74	1.11	5.6
7760	10JUN91	7020	9328	126	14.41	72.1
7760	13JUN91	7031	9432		10.0	-
7760	14JUN91	7033	9447		16.4	-
7760	15JUN91	7035	9514		6.5	-
7760	16JUN91	7038	9520		9.0	-
7760	17JUN91	7042	9529		4.6	-
7760	18JUN91	7044	9523		5.4	-
7760	19JUN91	7041	9527		0.4	-
7760	20JUN91	7041	9526		0.1	-
7760	21JUN91	7041	9526		0.3	-
7760	22JUN91	7041	9527		2.8	-
7760	23JUN91	7042	9531		3.2	-
7760	24JUN91	7040	9531		4.3	-
7760	25JUN91	7043	9531		0.8	4.1
7760	30JUN91	7041	9537		0.7	3.6
7760	05JUL91	7045	9540	194	1.89	9.5
7760	10JUL91	7040	9543	210	4.29	21.5
7760	15JUL91	7046	9613	342	2.00	10.0
7760	20JUL91	7050	9602	246	1.38	6.9
7760	25JUL91	7049	9551	178	1.74	8.7
7760	30JUL91	7046	9540	216	4.51	22.6
7760	04AUG91	7058	9546	210	2.07	10.4
7760	09AUG91	7056	9530	150	10.04	50.2
7760	14AUG91	7034	9442	350	2.67	13.4
7760	19AUG91	7027	9437	299	6.50	32.5
7760	24AUG91	7012	9410	156	0.53	2.7
7760	29AUG91	7011	9413	99	0.45	2.3

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7760	03SEP91	7012	9411	99	4.59	23.0
7760	08SEP91	7024	9420	67	12.39	61.9
7760	13SEP91	6951	9404	92	2.05	10.3
7760	18SEP91	6953	9419	68	2.17	10.8
7760	23SEP91	6953	9402	111	7.38	36.9
7760	28SEP91	6939	9321	70	2.43	12.2
7760	03OCT91	6941	9339	51	3.15	15.8
7760	08OCT91	6948	9353	145	10.24	51.2
7760	13OCT91	6925	9309	104	2.07	10.4
7760	18OCT91	6920	9316	62	6.96	34.8
7760	23OCT91	6902	9301	141	5.40	27.0
7760	28OCT91	6850	9238	117	6.45	32.3
7760	02NOV91	6843	9154	134	7.44	32.7
7760	07NOV91	6823	9149	221	8.19	40.9
7760	12NOV91	6841	9224	211	0.94	4.7
7760	17NOV91	6841	9231	87	0.39	1.9
7760	22NOV91	6842	9230	52	0.77	3.8
7760	27NOV91	6841	9235	177	1.48	7.4
7760	02DEC91	6841	9224	192	0.65	3.3
7760	07DEC91	6840	9228	202	0.39	1.9
7760	12DEC91	6839	9229	346	1.55	7.8
7760	17DEC91	6836	9221	216	2.08	10.4
7760	22DEC91	6841	9228	224	1.27	6.4
7760	27DEC91	6840	9219	-	0.54	2.7
7760	01JAN92	6840	9223	208	0.77	3.8
7760	06JAN92	6839	9218	331	4.98	24.9
7760	11JAN92	6842	9142	205	3.19	15.9
7760	16JAN92	6848	9125	194	0.55	2.8
7760	21JAN92	6847	9122	339	2.82	14.1
7760	26JAN92	6847	9101	275	1.37	6.8
7760	31JAN92	6844	9055	136	1.10	5.5
7760	05FEB92	6842	9049	156	1.51	7.5
7760	10FEB92	6838	9051	240	1.51	7.5
7760	15FEB92	6842	9053	-	0.94	4.7
7760	20FEB92	6842	9100	176	0.75	3.8
7760	25FEB92	6844	9101	200	1.23	6.2
7760	01MAR92	6841	9057	195	0.84	4.2
7760	06MAR92	6843	9060	149	0.65	3.2
7760	11MAR92	6844	9104	169	0.00	0.0
7760	16MAR92	6844	9104	153	1.31	6.6

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7760	21MAR92	6842	9112	95	0.46	2.3
7760	26MAR92	6843	9110	55	1.46	7.3
7760	31MAR92	6846	9117	68	3.40	17.0
7760	05APR92	6855	9122	75	4.11	20.5
7760	10APR92	6902	9146	131	3.77	18.9
7760	15APR92	6908	9123	56	0.84	4.2
7760	20APR92	6910	9120	138	0.79	4.0
7760	25APR92	6912	9118	66	2.36	11.8
7760	30APR92	6918	9124	137	3.23	16.2
7760	05MAY92	6916	9148	97	1.57	7.8
7760	10MAY92	6920	9152	-	4.23	21.2
7760	15MAY92	6929	9212	86	5.09	25.5
7760	20MAY92	6939	9239	126	4.08	20.4
7760	25MAY92	6950	9241	68	8.62	43.1
7760	30MAY92	7013	9231	-	3.03	15.2
7760	04JUN92	7021	9236	-	2.31	11.6
7760	09JUN92	7027	9241	121	2.73	13.6
7760	14JUN92	7034	9248	78	0.94	4.7
7760	19JUN92	7033	9255	52	3.97	19.84
7760	24JUN92	7032	9327	75	4.80	24.0
7760	29JUN92	7036	9404	69	5.58	27.9
7760	04JUL92	7038	9449	44	5.03	25.1
7760	09JUL92	7041	9529	68	1.96	9.8
7760	14JUL92	7041	9545	90	3.88	19.4
7760	19JUL92	7047	9611	203	0.52	2.6
7760	24JUL92	7048	9614	118	2.17	10.8
7760	29JUL92	7052	9627	185	2.87	14.4
7760	03AUG92	7047	9609	220	2.05	10.3
7760	13AUG92	7042	9539	185	4.04	20.2
7760	18AUG92	7032	9526	103	3.71	18.6
7760	23AUG92	7026	9502	109	1.29	6.5
7760	28AUG92	7025	9452	54	0.74	3.7
7760	02SEP92	7025	9446	58	3.72	18.6
7760	07SEP92	7035	9443	41	2.12	10.6
7760	10SEP92	7032	9448	33	0.39	1.9
7760	15SEP92	7033	9449	34	0.52	2.6
7760	20SEP92	7032	9446	52	4.89	24.5
7760	25SEP92	7019	9439	131	11.73	58.7
7760	30SEP92	6953	9346	-	12.01	60.1
7760	05OCT92	6925	9259	56	2.36	11.8

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7762	13APR91	6855	9302	69	-	-
7762	18APR91	6856	9309	110	3.43	17.2
7762	23APR91	6905	9315	69	2.61	13.1
7762	28APR91	6912	9317	59	2.23	11.1
7762	03MAY91	6918	9318	85	11.90	59.5
7762	08MAY91	6946	9403	337	4.79	23.9
7762	13MAY91	6958	9417	51	0.45	2.3
7762	18MAY91	6959	9415	92	7.42	37.1
7762	23MAY91	7014	9454	100	4.59	22.9
7762	28MAY91	7025	9511	59	4.20	21.0
7762	02JUN91	7035	9527	46	0.87	4.4
7762	05JUN91	7036	9530	53	1.50	7.5
7762	10JUN91	7032	9528	55	2.43	12.2
7762	13JUN91	7036	9528	-	4.04	-
7762	14JUN91	7037	9522	-	1.60	-
7762	15JUN91	7038	9520	-	1.79	-
7762	16JUN91	7037	9523	-	3.35	-
7762	17JUN91	7038	9528	-	0.99	-
7762	18JUN91	7037	9529	-	0.76	-
7762	19JUN91	7037	9530	-	2.42	-
7762	20JUN91	7038	9532	-	1.29	-
7762	21JUN91	7038	9530	-	1.86	-
7762	22JUN91	7038	9528	-	3.26	-
7762	23JUN91	7039	9533	-	1.50	-
7762	24JUN91	7039	9533	-	1.75	-
7762	25JUN91	7040	9531	-	2.77	-
7762	30JUN91	7039	9534	273	0.80	4.1
7762	05JUL91	7041	9535	374	0.38	1.9
7762	10JUL91	7040	9536	400	2.36	11.8
7762	15JUL91	7045	9548	476	3.48	17.4
7762	20JUL91	7052	9607	376	3.38	16.9
7762	25JUL91	7046	9546	335	3.78	18.9
7762	30JUL91	7051	9519	434	3.80	19.0
7762	04AUG91	7054	9449	318	0.96	4.8
7762	09AUG91	7056	9454	347	6.36	31.4
7762	14AUG91	7040	9437	343	0.36	1.8
7762	19AUG91	7040	9440	268	4.14	20.7
7762	24AUG91	7030	9425	331	1.35	6.7
7762	29AUG91	7034	9427	193	0.19	0.9
7762	03SEP91	7036	9439	273	0.83	4.1
7762	08SEP91	7035	9440	374	0.39	2.0

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7762	13SEP91	7005	9351	400	2.36	11.8
7762	18SEP91	7001	9407	476	3.48	17.4
7762	23SEP91	7010	9437	376	3.39	16.9
7762	28SEP91	7014	9422	335	3.77	18.9
7762	03OCT91	6957	9334	434	3.81	19.1
7762	08OCT91	6947	9333	318	0.96	4.8
7762	13OCT91	6945	9334	347	6.28	31.4
7762	18OCT91	7002	9344	343	0.37	1.9
7762	23OCT91	6915	9313	268	4.14	20.7
7762	28OCT91	6860	9300	331	1.50	7.5
7762	02NOV91	6845	9223	219	1.65	8.3
7762	07NOV91	6838	9135	135	0.39	1.9
7762	12NOV91	6829	9209	244	12.69	63.4
7762	17NOV91	6849	9147	327	2.51	12.6
7762	22NOV91	6853	9129	173	5.04	25.2
7762	27NOV91	6846	9148	230	2.40	10.5
7762	02DEC91	6845	9146	118	8.74	43.7
7762	07DEC91	6843	9150	190	3.71	18.6
7762	13DEC91	6842	9156	326	0.75	3.8
7762	18DEC91	6842	9156	219	6.43	32.2
7762	23DEC91	6841	9156	206	17.87	89.4
7762	28DEC91	6842	9209	206	5.82	29.1
7762	02JAN92	6841	9149	288	7.44	37.2
7762	07JAN92	6843	9144	202	6.96	34.8
7762	12JAN92	6843	9149	123	5.69	28.5
7762	20JAN92	6852	9127	157	7.98	39.9
7762	25JAN92	6853	9132	113	2.83	14.2
7762	30JAN92	6854	9137	164	3.63	18.2
7762	05FEB92	6855	9136	130	0.46	2.3
7762	10FEB92	6855	9134	177	0.92	4.6
7762	15FEB92	6855	9134	186	0.74	3.7
7762	20FEB92	6857	9116	-	0.00	0.0
7762	25FEB92	6900	9058	112	0.37	1.8
7762	29FEB92	6903	9049	131	1.79	8.9
7762	04MAR92	6901	9050	169	2.72	13.6
7762	10MAR92	6901	9050	65	1.00	5.0
7762	16MAR92	6902	9045	123	0.67	3.4
7762	22MAR92	6903	9051	159	2.78	13.9
7762	27MAR92	6900	9045	-	0.76	3.8
7762	01APR92	6906	9043	-	0.76	3.8
7762	06APR92	6904	9042	-	0.33	1.6

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7762	11APR92	6908	9047	-	0.27	1.4
7762	16APR92	6904	9043	-	0.00	0.0
7762	21APR92	6907	9043	-	2.51	12.6
7762	26APR92	6908	9048	-	2.64	13.4
7762	01MAY92	6918	9120	-	2.04	10.2
7762	06MAY92	6922	9136	-	0.94	4.7
7762	11MAY92	6926	9144	-	0.00	0.0
7762	16MAY92	6952	9234	-	0.63	3.2
7762	21MAY92	7008	9238	-	0.73	3.7
7762	26MAY92	7016	9249	-	1.37	6.8
7762	31MAY92	7021	9255	54	2.24	11.2
7762	01JUN92	7040	9302	-	2.05	-
7762	02JUN92	7040	9307	-	4.22	-
7762	03JUN92	7044	9304	-	10.25	-
7762	04JUN92	7048	9327	-	6.82	-
7762	05JUN92	7044	9316	-	0.34	-
7762	06JUN92	7043	9316	-	5.24	-
7762	07JUN92	7048	9315	-	6.67	-
7762	08JUN92	7042	9315	-	2.01	-
7762	09JUN92	7044	9315	-	4.54	-
7762	10JUN92	7047	9324	-	5.55	-
7762	11JUN92	7045	9338	-	3.39	-
7762	12JUN92	7043	9343	-	3.01	-
7762	13JUN92	7040	9347	-	2.85	-
7762	14JUN92	7042	9353	-	3.03	-
7762	15JUN92	7040	9348	-	8.23	-
7762	16JUN92	7047	9348	-	1.52	-
7762	17JUN92	7046	9344	-	2.81	-
7762	18JUN92	7048	9351	-	3.59	-
7762	19JUN92	7045	9347	-	6.41	-
7762	20JUN92	7049	9359	-	12.61	-
7762	21JUN92	7048	9393	-	13.96	-
7762	22JUN92	7058	9413	-	4.35	-
7762	23JUN92	7055	9419	-	1.74	-
7762	24JUN92	7056	9415	-	0.84	-
7762	25JUN92	7055	9413	-	3.75	-
7762	26JUN92	7058	9418	-	4.06	-
7762	27JUN92	7055	9420	-	2.00	-
7762	28JUN92	7053	9420	-	5.61	28.1
7762	03JUL92	7030	9416	98	2.56	12.8

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7762	08JUL92	7032	9438	119	1.81	9.05
7762	13JUL92	7043	9531	80	11.59	59.8
7762	18JUL92	7046	9538	296	5.95	29.8
7762	23JUL92	7045	9541	62	3.27	16.4
7762	28JUL92	7052	9555	106	2.00	10.0
7762	02AUG92	7104	9531	122	3.76	18.8
7762	07AUG92	7058	9524	94	1.89	9.5
7762	12AUG92	7048	9502	135	2.71	13.6
7762	17AUG92	7050	9450	99	0.53	2.6
7762	22AUG92	7050	9443	137	4.54	22.7
7762	27AUG92	7052	9447	103	11.50	57.5
7762	01SEP92	7053	9444	141	17.93	89.6
7762	06SEP92	7051	9446	178	2.82	14.1
7762	11SEP92	7053	9440	311	7.69	38.5
7764	13JUN91	6852	8821	-	5.73	-
7764	14JUN91	6855	8824	-	5.97	-
7764	15JUN91	6857	8831	-	5.78	-
7764	16JUN91	6854	8825	-	4.59	-
7764	17JUN91	6852	8829	-	0.00	-
7765	13APR91	6823	8926	450	0.52	2.6
7765	18APR91	6822	8927	418	3.10	15.5
7765	23APR91	6821	8929	410	5.31	26.5
7765	28APR91	6823	8930	527	2.38	11.9
7765	03MAY91	6823	8930	511	4.57	22.8
7765	08MAY91	6823	8904	407	1.64	8.2
7765	13MAY91	6813	8848	372	0.85	4.3
7765	18MAY91	6811	8827	295	0.89	4.4
7765	23MAY91	6807	8825	209	0.52	2.6
7765	28MAY91	6808	8825	181	0.78	3.9
7765	02JUN91	6826	8804	226	1.04	5.2
7765	05JUN91	6824	8754	170	0.83	4.2
7765	10JUN91	6803	8900	41	1.14	5.7
7765	13JUN91	6712	8530	-	2.24	-
7765	14JUN91	6712	8533	-	2.57	-
7765	15JUN91	6713	8530	-	1.98	-
7765	16JUN91	6712	8532	-	4.13	-
7765	17JUN91	6711	8536	-	2.63	-
7765	18JUN91	6711	8539	-	6.17	-
7765	19JUN91	6713	8535	-	6.51	-

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7765	20JUN91	6711	8542	-	5.14	-
7765	21JUN91	6714	8540	-	6.19	-
7765	22JUN91	6715	8532	-	2.82	-
7765	23JUN91	6714	8535	-	1.69	-
7765	24JUN91	6714	8532	-	7.98	-
7765	25JUN91	6712	8542	-	31.83	-
7765	30JUN91	6712	8626	192	1.26	6.3
7765	05JUL91	6710	8619	42	3.55	17.8
7765	10JUL91	6721	8631	107	4.31	21.5
7765	15JUL91	6721	8633	26	2.98	14.9
7765	20JUL91	6723	8649	39	1.51	7.6
7765	25JUL91	6722	8644	26	0.37	1.8
7765	30JUL91	6721	8644	59	7.26	36.3
7765	04AUG91	6722	8645	54	2.59	12.9
7765	09AUG91	6725	8648	60	11.95	59.8
7765	14AUG91	6720	8646	490	34.92	174.6
7765	19AUG91	6719	8650	41	1.14	5.7
7765	24AUG91	6708	8716	104	1.41	7.1
7765	29AUG91	6713	8732	168	6.32	31.6
7765	03SEP91	6802	8824	192	1.25	6.3
7765	08SEP91	6809	8854	235	4.42	22.1
7765	13SEP91	6825	8914	288	0.28	1.4
7765	18SEP91	6828	8920	222	2.40	12.0
7765	23SEP91	6834	8910	265	0.80	4.0
7765	28SEP91	6835	8924	225	0.37	1.8
7765	03OCT91	6806	8902	264	0.40	2.0
7765	08OCT91	6738	9303	260	1.19	5.9
7765	13OCT91	6706	9358	248	1.87	9.3
7765	18OCT91	6707	9308	186	0.68	3.4
7765	23OCT91	6712	9321	253	5.52	27.6
7765	28OCT91	6701	9214	206	2.95	14.8
7765	02NOV91	6710	9137	255	19.58	96.1
7765	07NOV91	6727	9137	298	4.89	24.4
7765	12NOV91	6708	9219	151	6.53	32.6
7765	17NOV91	6708	9128	192	1.38	6.9
7765	22NOV91	6730	9113	109	2.60	13.0
7765	27NOV91	6739	9131	183	1.93	9.6
7765	02DEC91	6739	9132	149	11.16	55.8
7765	07DEC91	6738	9133	266	35.20	176.0
7765	12DEC91	6738	9129	306	14.22	71.1
7765	17DEC91	6735	9119	145	7.22	36.1

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7765	22DEC91	6737	9118	167	2.63	13.5
7765	27DEC91	6733	9137	159	10.48	52.4
7765	01JAN92	6729	9146	159	6.29	31.4
7765	06JAN92	6733	9151	138	6.30	31.5
7765	11JAN92	6732	9151	213	9.25	46.3
7765	16JAN92	6745	9153	214	7.34	36.7
7766	13JUN91	6752	8825	-	0.34	-
7766	14JUN91	6752	8825	-	3.56	-
7766	15JUN91	6753	8822	-	3.48	-
7766	16JUN91	6754	8826	-	3.48	-
7766	17JUN91	6753	8824	-	3.34	-
7766	18JUN91	6754	8821	-	1.74	-
7766	19JUN91	6753	8823	-	0.72	-
7766	20JUN91	6753	8823	-	8.66	-
7766	21JUN91	6757	8829	-	4.21	-
7766	22JUN91	6759	8830	-	6.47	-
7766	23JUN91	6800	8839	-	2.04	-
7766	24JUN91	6759	8841	-	0.90	-
7766	25JUN91	6759	8842	-	2.3	11.7
7766	30JUN91	6758	8854	81	0.56	2.8
7766	05JUL91	6804	8830	76	1.80	9.0
7766	10JUL91	6825	8828	55	0.75	3.7
7766	15JUL91	6846	8847	34	3.07	15.3
7766	20JUL91	6847	8846	55	1.96	9.8
7766	25JUL91	6844	8859	30	1.64	8.2
7766	30JUL91	6849	8852	43	0.37	1.8
7766	04AUG91	6845	8904	30	4.82	24.1
7766	09AUG91	6850	8855	35	2.55	12.7
7766	14AUG91	6849	8910	116	3.80	19.0
7766	19AUG91	6843	8847	273	2.84	14.2
7766	24AUG91	6848	8903	139	1.98	9.9
7766	29AUG91	6846	8857	254	1.71	8.6
7766	03SEP91	6850	8910	235	4.00	20.0
7766	08SEP91	6844	8913	180	7.79	38.9
7766	13SEP91	6847	8913	264	8.19	40.9
7766	18SEP91	6847	8908	164	0.39	1.9
7766	23SEP91	6844	8914	183	2.07	10.3
7766	28SEP91	6828	8922	257	2.08	10.4
7766	03OCT91	6811	8854	203	2.19	10.9
7766	08OCT91	6813	8829	175	2.21	11.1

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7766	13OCT91	6808	8833	200	2.04	10.2
7767	13APR91	6849	9036	273	2.84	14.2
7767	18APR91	6950	9040	167	1.09	5.3
7767	23APR91	6855	9044	117	2.29	11.4
7767	28APR91	6901	9053	108	2.26	11.3
7767	03MAY91	6906	9056	154	1.11	5.5
7767	08MAY91	6911	9125	129	0.67	3.4
7767	13MAY91	6921	9149	86	1.37	6.8
7767	18MAY91	6933	9226	55	6.03	30.2
7767	23MAY91	6938	9246	168	7.37	36.8
7767	28MAY91	7008	9260	118	3.52	17.6
7767	02JUN91	7026	9335	77	1.93	9.6
7767	05JUN91	7034	9346	91	3.01	15.1
7767	10JUN91	7045	9309	155	5.02	25.1
7767	13JUN91	7053	9442	-	13.91	-
7767	14JUN91	7058	9459	-	8.91	-
7767	15JUN91	7102	9508	-	4.46	-
7767	16JUN91	7104	9508	-	9.66	-
7767	17JUN91	7109	9513	-	5.67	-
7767	18JUN91	7112	9518	-	1.71	-
7767	19JUN91	7112	9521	-	4.78	-
7767	20JUN91	7115	9518	-	3.61	-
7767	21JUN91	7114	9524	-	2.68	-
7767	22JUN91	7115	9528	-	3.09	-
7767	23JUN91	7116	9532	-	8.83	-
7767	24JUN91	7120	9527	-	7.15	-
7767	25JUN91	7117	9528	-	20.49	-
7767	30JUN91	7106	9530	130	1.89	9.4
7767	05JUL91	7103	9528	131	4.25	21.3
7767	10JUL91	7109	9436	191	4.86	24.3
7767	15JUL91	7060	9433	113	6.55	32.7
7767	20JUL91	7059	9460	148	3.18	15.9
7767	25JUL91	7112	9522	174	11.26	56.3
7767	30JUL91	7115	9456	184	7.98	39.9
7767	04AUG91	7117	9505	99	5.44	27.2
7767	09AUG91	7102	9440	126	6.10	30.5
7767	14AUG91	7032	9345	136	15.16	75.8
7767	19AUG91	7021	9356	155	5.03	25.2
7767	24AUG91	7005	9330	177	1.91	9.5
7767	29AUG91	7010	9312	239	4.08	20.4

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7767	03SEP91	7012	9333	256	1.14	5.7
7767	08SEP91	7014	9328	253	6.63	33.1
7767	13SEP91	7002	9325	158	3.35	16.7
7767	18SEP91	6958	9306	246	3.28	16.4
7767	23SEP91	6957	9334	298	5.49	27.5
7767	28SEP91	6952	9319	286	3.29	16.4
7767	03OCT91	6935	9234	306	1.30	6.5
7767	08OCT91	6910	9255	245	6.31	31.5
7767	13OCT91	6856	9314	254	12.98	64.9
7767	18OCT91	6854	9301	293	4.30	21.5
7767	23OCT91	6847	9303	358	6.77	33.8
7767	28OCT91	6832	9238	340	2.93	14.6
7767	02NOV91	6812	9222	289	2.74	13.7
7767	07NOV91	6735	9306	243	0.97	4.8
7767	12NOV91	6726	9338	157	4.46	22.3
7767	17NOV91	6712	9246	224	2.83	14.1
7767	22NOV91	6709	9306	167	3.58	17.9
7767	27NOV91	6722	9305	192	2.66	13.3
7767	02DEC91	6728	9304	130	8.55	42.7
7767	07DEC91	6727	9315	408	9.66	48.3
7767	12DEC91	6733	9308	155	5.77	28.8
7767	17DEC91	6737	9320	177	1.88	9.4
7767	22DEC91	6751	9226	165	2.61	13.1
7767	27DEC91	6743	9215	273	6.50	32.5
7767	01JAN92	6743	9212	219	7.73	38.6
7767	06JAN92	6746	9211	265	15.02	75.1
7767	11JAN92	6750	9201	293	5.63	28.2
7767	16JAN92	6749	9206	153	9.06	45.3
7767	21JAN92	6747	9224	227	3.08	15.4
7767	26JAN92	6730	9211	198	4.82	24.1
7767	31JAN92	6728	9202	133	2.23	11.1
7767	05FEB92	6724	9204	95	1.61	8.1
7767	10FEB92	6728	9203	88	2.43	12.1
7767	15FEB92	6732	9156	78	2.25	11.3
7767	20FEB92	6742	9144	105	9.19	45.9
7767	25FEB92	6742	9146	131	3.34	16.7
7767	01MAR92	6743	9159	92	0.42	2.1
7767	06MAR92	6742	9154	73	1.12	5.6
7767	11MAR92	6741	9155	95	2.04	10.2
7767	16MAR92	6743	9206	62	0.79	3.9
7767	19MAR92	6748	9218	59	2.63	13.1

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7767	24MAR92	6818	9218	66	6.56	27.8
7767	29MAR92	6832	9228	72	1.48	7.4
7767	03APR92	6852	9205	95	1.51	7.5
7767	08APR92	6920	9209	72	1.49	7.4
7767	13APR92	6925	9202	75	1.78	8.9
7767	18APR92	6925	9207	74	4.07	20.3
7767	23APR92	6924	9206	94	0.28	1.4
7767	28APR92	6929	9217	55	1.86	9.3
7767	03MAY92	6952	9248	59	0.79	3.9
7767	08MAY92	7013	9258	86	0.40	2.0
7767	13MAY92	7029	9254	45	1.72	8.6
7767	18MAY92	7043	9255	40	4.17	20.8
7767	23MAY92	7053	9309	104	11.12	55.6
7767	28MAY92	7056	9325	155	5.36	26.8
7767	01JUN92	7095	9343	-	4.74	-
7767	02JUN92	7092	9335	-	9.35	-
7767	03JUN92	7095	9359	-	7.87	-
7767	04JUN92	7100	9342	-	6.60	-
7767	05JUN92	7094	9346	-	2.34	-
7767	06JUN92	7095	9341	-	0.73	-
7767	07JUN92	7095	9343	-	0.83	-
7767	08JUN92	7095	9341	-	4.61	-
7767	09JUN92	7095	9353	-	2.00	-
7767	10JUN92	7097	9353	-	2.58	-
7767	11JUN92	7099	9350	-	1.18	-
7767	12JUN92	7100	9349	-	4.38	-
7767	13JUN92	7104	9351	-	9.40	-
7767	14JUN92	7111	9363	-	1.61	-
7767	15JUN92	7113	9362	-	4.04	-
7767	16JUN92	7110	9371	-	1.64	-
7767	17JUN92	7112	9372	-	2.90	-
7767	18JUN92	7113	9379	-	8.79	-
7767	19JUN92	7121	9387	-	9.01	-
7767	20JUN92	7118	9411	-	21.76	-
7767	21JUN92	7133	9451	-	11.57	-
7767	22JUN92	7133	9483	-	12.24	-
7767	23JUN92	7129	9515	-	2.45	-
7767	24JUN92	7131	9516	-	5.67	-
7767	25JUN92	7126	9513	-	5.05	-
7767	30JUN92	7113	9459	118	9.41	47.1
7767	05JUL92	7113	9503	174	7.88	39.4

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7767	10JUL92	7116	9456	56	5.95	29.8
7767	15JUL92	7117	9520	138	5.19	25.9
7767	20JUL92	7114	9527	108	4.08	20.4
7767	25JUL92	7117	9527	100	2.24	11.2
7767	30JUL92	7111	9530	91	0.12	0.6
7767	04AUG92	7107	9511	79	0.37	1.8
7767	09AUG92	7054	9429	162	1.17	5.8
7767	14AUG92	7042	9423	175	3.16	15.8
7767	19AUG92	7023	9421	92	9.88	49.4
7767	24AUG92	7007	9416	162	2.66	13.3
7767	29AUG92	6958	9332	97	0.88	4.4
7767	03SEP92	7009	9316	116	0.48	2.4
7767	08SEP92	7019	9303	132	1.39	6.9
7767	13SEP92	7019	9321	186	2.88	14.4
7767	18SEP92	7021	9304	348	1.39	6.9
7767	23SEP92	6958	9235	381	1.11	5.5
7767	28SEP92	6923	9247	348	2.25	11.2
7767	03OCT92	6849	9307	411	2.71	13.5
7767	08OCT92	6760	9223	411	7.00	35.0
7767	13OCT92	6717	9243	263	4.51	22.5
7767	18OCT92	6712	9302	272	7.04	35.2
7767	23OCT92	6644	9313	326	5.96	29.8
7767	28OCT92	6620	9355	224	6.49	32.4
7767	02NOV92	6531	9505	361	4.55	22.7
7767	07NOV92	6504	9609	350	4.05	20.2
7767	12NOV92	6447	9528	251	2.25	11.2
7767	17NOV92	6436	9442	184	2.25	11.2
7767	20MAR93	6513	9451	220	9.27	46.3
7767	25MAR93	6511	9458	546	13.06	65.3
7767	30MAR93	6535	9504	359	12.87	64.3
7768	13APR91	6831	9313	386	16.18	80.9
7768	18APR91	6835	9309	261	3.29	16.4
7768	23APR91	6903	9305	176	10.50	52.5
7768	28APR91	6908	9300	220	10.84	54.2
7768	03MAY91	6927	9306	359	21.01	105.3
7768	08MAY91	6934	9314	272	14.08	70.4
7768	13MAY91	7007	9325	189	9.01	45.1
7768	18MAY91	7021	9319	206	8.35	41.7
7768	23MAY91	7030	9322	75	3.44	17.2
7768	28MAY91	7051	9344	908	3.70	18.5

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7768	02JUN91	7101	9344	100	1.20	6.0
7768	05JUN91	7116	9336	70	5.00	25.0
7768	10JUN91	7123	9350	40	5.70	28.5
7768	13JUN91	7135	9415	-	0.15	-
7768	14JUN91	7135	9415	-	2.80	-
7768	15JUN91	7134	9411	-	3.77	-
7768	16JUN91	7136	9407	-	4.34	-
7768	17JUN91	7135	9413	-	1.13	-
7768	18JUN91	7135	9414	-	3.36	-
7768	19JUN91	7134	9419	-	2.18	-
7768	20JUN91	7134	9423	-	1.64	-
7768	21JUN91	7135	9424	-	2.28	-
7768	22JUN91	7135	9420	-	1.34	-
7768	23JUN91	7134	9420	-	2.50	-
7768	24JUN91	7134	9424	-	5.17	-
7768	25JUN91	7132	9419	-	6.43	-
7768	30JUN91	7135	9416	75	7.08	35.4
7768	05JUL91	7137	9416	105	2.79	13.9
7768	10JUL91	7138	9352	56	12.31	61.5
7768	15JUL91	7131	9352	99	5.24	26.2
7768	20JUL91	7133	9353	119	3.36	16.8
7768	25JUL91	7121	9340	101	8.24	41.2
7768	30JUL91	7103	9319	138	3.71	18.5
7768	04AUG91	7106	9318	53	9.40	47.0
7768	09AUG91	7051	9319	128	3.08	15.4
7768	14AUG91	7028	9250	40	5.70	28.5
7768	19AUG91	7021	9254	44	1.23	6.2
7768	24AUG91	7010	9306	50	1.49	7.4
7768	29AUG91	7005	9313	194	1.26	6.3
7768	03SEP91	7015	9310	112	0.74	3.7
7768	08SEP91	6954	9313	133	2.83	14.1
7768	13SEP91	6942	9329	203	2.59	12.9
7768	18SEP91	6939	9304	171	0.75	3.7
7768	23SEP91	6933	9323	195	4.70	23.5
7768	28SEP91	6929	9313	216	7.13	35.6
7768	03OCT91	6922	9319	244	1.12	5.6
7768	08OCT91	6912	9335	224	5.56	27.8
7768	13OCT91	6909	9349	224	9.24	46.2
7768	18OCT91	6914	9319	193	2.64	13.2
7768	23OCT91	6847	9305	203	4.34	21.7
7768	28OCT91	6810	9255	197	2.05	10.3

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7768	02NOV91	6805	9254	150	3.72	18.6
7768	07NOV91	6804	9324	113	7.79	38.9
7768	12NOV91	6759	9251	120	4.89	24.5
7768	18NOV91	6802	9134	108	3.40	17.0
7768	23NOV91	6805	9133	176	3.31	16.5
7768	27NOV91	6806	9133	99	2.00	10.0
7768	02DEC91	6805	9128	113	2.71	13.5
7768	07DEC91	6805	9132	65	4.26	21.3
7768	12DEC91	6805	9134	69	2.15	10.7
7768	17DEC91	6808	9130	96	4.36	21.8
7768	22DEC91	6810	9127	80	10.18	50.9
7768	27DEC91	6807	9133	161	13.78	68.9
7768	01JAN92	6806	9138	91	1.86	9.3
7768	06JAN92	6808	9124	-	4.17	20.8
7768	11JAN92	6808	9121	106	4.94	24.7
7768	16JAN92	6804	9132	81	8.95	44.7
7768	21JAN92	6806	9140	-	1.12	5.6
7768	26JAN92	6806	9138	34	0.46	2.3
7768	31JAN92	6806	9150	-	0.78	3.9
7768	05FEB92	6807	9125	46	0.55	2.7
7768	10FEB92	6806	9152	-	0.28	1.4
7768	15FEB92	6804	9156	43	1.24	6.2
7768	20FEB92	6804	9159	-	0.85	4.2
7768	25FEB92	6807	9158	52	1.39	6.9
7768	02MAR92	6805	9155	40	0.78	3.9
7768	05MAR92	6805	9153	89	2.07	10.3
7768	10MAR92	6805	9153	85	0.41	2.1
7768	15MAR92	6804	9151	19	2.12	10.6
7768	20MAR92	6807	9201	19	1.33	6.7
7768	25MAR92	6806	9154	44	0.28	1.4
7768	30MAR92	6803	9157	54	1.66	8.3
7768	04APR92	6807	9149	78	3.47	17.4
7768	09APR92	6818	9141	62	3.75	18.7
7768	14APR92	6847	9133	38	0.92	4.6
7768	19APR92	6908	9157	39	0.42	2.1
7768	24APR92	6913	9127	39	1.12	5.6
7768	29APR92	6913	9137	26	0.71	3.5
7768	04MAY92	6918	9151	23	0.46	2.3
7768	09MAY92	6920	9150	-	0.00	0.0
7768	14MAY92	6931	9221	-	0.46	2.3
7768	18MAY92	6939	9244	65	1.77	8.8

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7768	23MAY92	7014	9315	53	1.04	5.2
7768	28MAY92	7025	9311	20	1.19	5.6
7768	02JUN92	7050	9273	41	4.65	-
7768	04JUN92	7060	9313	-	3.85	-
7768	05JUN92	7066	9305	30	1.78	-
7768	06JUN92	7065	9308	-	3.18	-
7768	10JUN92	7077	9311	96	0.86	-
7768	11JUN92	7077	9312	-	1.87	-
7768	15JUN92	7083	9301	79	2.96	14.7
7768	20JUN92	7095	9317	94	5.99	-
7768	21JUN92	7091	9307	-	4.06	-
7768	25JUN92	7101	9338	32	3.03	-
7768	26JUN92	7103	9333	-	3.17	-
7768	30JUN92	7109	9320	26	2.61	13.1
7768	01JUL92	7109	9315	-	0.75	3.7
7768	06JUL92	7113	9341	41	5.74	28.7
7768	11JUL92	7122	9417	52	5.24	26.2
7768	16JUL92	7128	9426	-	13.55	67.7
7768	21JUL92	7135	9414	43	4.11	20.5
7768	26JUL92	7138	9355	43	3.83	19.2
7768	31JUL92	7138	9355	89	6 43	32.2
7768	05AUG92	7131	9350	-	3.00	15.0
7768	10AUG92	7122	9342	-	1.71	8.5
7768	15AUG92	7109	9333	92	2.81	14.1
7768	20AUG92	7050	9302	58	1.56	7.8
7768	25AUG92	7029	9305	44	3.05	15.2
7768	30AUG92	7024	9304	58	2.99	14.9
7768	04SEP92	7016	9246	58	3.44	17.2
7768	09SEP92	6947	9312	87	5.42	27.1
7768	16SEP92	6934	9305	85	2.46	12.3
7768	21SEP92	6935	9320	86	2.95	14.7
7768	26SEP92	6936	9319	95	2.48	12.4
7768	01OCT92	6925	9310	65	0.00	0.0
7768	06OCT92	6926	9306	96	2.66	13.3
7768	11OCT92	6919	9243	131	3.47	17.3
7768	16OCT92	6919	9224	127	4.93	24.6
7768	21OCT92	6918	9209	123	7.97	39.8
7768	26OCT92	6907	9142	156	7.79	38.9
7768	31OCT92	6856	9115	181	1.86	9.3
7769	13APR91	6915	9233	100	11.24	56.2

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7769	18APR91	6917	9233	92	3.50	17.5
7769	23APR91	6923	9229	95	1.97	9.8
7769	28APR91	6931	9242	88	0.39	1.9
7769	03MAY91	6934	9244	53	4.24	21.2
7769	08MAY91	6944	9248	102	0.64	3.2
7769	13MAY91	7015	9260	84	3.97	19.8
7769	18MAY91	7024	9259	50	2.49	12.4
7769	23MAY91	7026	9307	62	2.00	10.0
7769	28MAY91	7039	9317	42	5.41	27.1
7769	02JUN91	7058	9328	-	5.43	27.2
7769	05JUN91	7112	9349	86	1.33	6.6
7769	10JUN91	7106	9339	26	1.48	7.4
7769	13JUN91	7124	9445	-	1.91	-
7769	14JUN91	7125	9445	-	4.97	-
7769	15JUN91	7128	9441	-	1.90	-
7769	16JUN91	7128	9444	-	2.79	-
7769	17JUN91	7127	9446	-	3.56	-
7769	18JUN91	7128	9451	-	7.82	-
7769	19JUN91	7132	9448	-	5.25	-
7769	20JUN91	7129	9445	-	4.33	-
7769	21JUN91	7131	9448	-	5.56	-
7769	22JUN91	7128	9450	-	3.50	-
7769	23JUN91	7130	9449	-	4.72	-
7769	24JUN91	7128	9447	-	4.81	-
7769	25JUN91	7130	9445	79	3.41	17.4
7769	30JUN91	7133	9511	68	1.14	5.7
7769	05JUL91	7139	9528	73	3.74	18.7
7769	10JUL91	7140	9520	95	11.59	57.9
7769	15JUL91	7143	9527	174	3.34	16.7
7769	20JUL91	7140	9502	106	1.24	6.2
7769	25JUL91	7138	9510	38	4.97	24.8
7769	30JUL91	7133	9505	127	7.17	35.8
7769	04AUG91	7134	9504	45	9.61	48.1
7769	09AUG91	7131	9454	150	2.53	12.6
7769	14AUG91	7127	9423	185	11.14	55.7
7769	19AUG91	7121	9359	26	1.49	7.4
7769	24AUG91	7109	9340	40	0.37	1.8
7769	29AUG91	7057	9322	79	3.25	16.2
7769	03SEP91	7052	9351	101	2.98	14.9
7769	08SEP91	7038	9302	73	1.00	5.0
7769	13SEP91	7010	9233	58	1.38	6.9

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7769	18SEP91	6949	9245	48	3.11	15.5
7769	23SEP91	6940	9308	102	1.19	5.9
7769	28SEP91	6924	9309	56	1.94	9.7
7769	03OCT91	6922	9313	61	0.39	1.9
7769	08OCT91	6924	9312	105	1.62	8.1
7769	13OCT91	6921	9246	45	3.94	19.7
7769	18OCT91	6914	9238	15	3.60	18.0
7769	23OCT91	6839	9246	94	5.00	25.0
7769	28OCT91	6802	9230	98	4.95	24.7
7769	02NOV91	6758	9218	35	3.97	19.8
7769	07NOV91	6735	9237	36	7.92	39.6
7769	12NOV91	6716	9326	91	10.98	54.9
7769	17NOV91	6711	9241	89	7.93	39.6
7769	22NOV91	6722	9215	66	4.45	22.2
7769	27NOV91	6722	9216	36	5.93	29.6
7769	02DEC91	6714	9220	45	0.91	4.5
7769	07DEC91	6714	9208	24	0.75	3.7
7769	12DEC91	6711	9201	16	3.57	17.8
7769	17DEC91	6712	9156	81	2.80	14.0
7769	22DEC91	6711	9158	30	13.01	65.1
7769	27DEC91	6707	9154	41	13.88	69.4
7769	01JAN92	6700	9203	87	2.23	11.5
7769	06JAN92	6702	9152	36	8.93	44.6
7769	11JAN92	6703	9148	66	9.91	49.5
7769	16JAN92	6700	9151	38	6.72	33.6
7769	21JAN92	6657	9154	28	5.52	27.6
7769	26JAN92	6655	9156	30	0.14	0.6
7769	31JAN92	6652	9159	22	3.02	15.1
7769	05FEB92	6646	9146	28	1.72	8.6
7769	10FEB92	6653	9155	30	1.50	7.5
7769	15FEB92	6653	9154	20	0.81	4.1
7769	20FEB92	6653	9153	34	0.47	2.4
7769	25FEB92	6649	9139	17	1.59	7.9
7769	01MAR92	6650	9149	40	2.90	14.5
7769	06MAR92	6654	9152	119	1.76	8.8
7769	11MAR92	6655	9153	35	0.69	3.4
7769	16MAR92	6656	9153	21	1.19	5.9
7771	05APR91	6855	9326	-	0.80	4.0
7771	10APR91	6905	9331	-	1.19	5.9
7771	15APR91	6913	9321	142	2.92	14.6

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7771	20APR91	6913	9320	76	2.91	14.5
7771	25APR91	6930	9323	22	0.16	0.8
7771	30APR91	6947	9428	-	0.15	0.7
7771	05MAY91	6930	9323	29	2.52	12.6
7771	10MAY91	6947	9428	10	1.50	7.5
7771	15MAY91	6944	9429	26	1.54	7.7
7771	20MAY91	6944	9444	16	0.40	2.0
7771	26MAY91	6943	9437	11	0.37	1.8
7771	31MAY91	6951	9427	18	1.00	5.0
7771	02JUN91	6947	9425	-	1.65	8.3
7771	07JUN91	7008	9415	139	12.2	61.0
7771	09JUN91	7013	9417	-	0.58	2.9
7771	14JUN91	7041	9512	154	3.24	16.2
7771	19JUN91	7042	9511	175	0.13	0.6
7771	23JUN91	7044	9526	121	6.31	31.5
7771	28JUN91	7039	9519	130	10.48	52.4
7771	03JUL91	7038	9523	-	10.48	52.4
7771	08JUL91	7038	9536	130	10.48	52.4
7771	13JUL91	7039	9541	-	1.12	5.6
7771	18JUL91	7045	9541	116	1.92	9.6
7771	23JUL91	7053	9536	159	0.81	4.1
7771	28JUL91	7043	9509	117	3.23	16.1
7771	02AUG91	7029	9441	93	3.76	18.8
7771	06AUG91	7020	9439	211	7.88	39.4
7771	11AUG91	7015	9419	174	10.09	50.4
7771	19AUG91	7003	9413	282	0.39	1.9
7771	26AUG91	6951	9359	112	2.47	12.3
7771	31AUG91	6949	9410	-	2.04	10.2
7771	05SEP91	6942	9416	318	0.61	3.1
7771	10SEP91	6942	9424	315	1.60	8.0
7771	15SEP91	6929	9356	483	0.72	3.6
7771	20SEP91	6929	9354	404	2.22	11.1
7771	25SEP91	6937	9357	479	3.03	15.2
7771	30SEP91	6936	9329	362	4.95	24.7
7771	05OCT91	6924	9318	483	6.23	31.1
7771	10OCT91	6858	9317	443	4.18	20.9
7771	15OCT91	6852	9307	-	3.11	15.5
7771	20OCT91	6909	9254	460	2.82	14.1
7771	25OCT91	6844	9319	455	3.42	17.1
7771	30OCT91	6826	9234	415	1.59	7.9
7771	04NOV91	6810	9331	363	2.71	13.5

Appendiix C (cont'd).

Cow#	Date	Lat.	Long.	Activity	Distance km/day	Min. distance (5 days)
7771	09NOV91	6810	9317	341	1.03	5.1
7771	14NOV91	6816	9317	278	6.02	30.1
7771	19NOV91	6836	9232	230	0.26	1.3
7771	24NOV91	6826	9257	199	2.99	9.0
7771	29NOV91	6831	9325	344	3.63	18.1
7771	03DEC91	6831	9329	262	4.67	23.3
7771	07DEC91	6826	9339	249	9.63	48.1
7771	12DEC91	6826	9326	241	2.59	12.9
7771	17DEC91	6812	9419	311	6.53	32.5
7771	23DEC91	6755	9442	232	9.84	49.2
7771	29DEC91	6744	9528	216	9.03	45.1
7771	05JAN92	6741	9529	139	9.81	49.1
7771	11JAN92	6742	9523	210	1.93	9.6